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ABSTRACT

Curry's model of learning style framework with Claxton and Murrell's adaptations was used to study the profile of non-majors in a college biology course. The purpose of the study was to provide empirically derived data in both a qualitative and quantitative format of the non-major to improve the course. Over 600 students were administered the Learning Style Profile (LSP) and the Myers-Briggs Type Indicator (MBTI) to determine the students' learning styles as a predictor for success in the course. The differences between the MBTI profile and other profiles published were examined among sample groups. Selection Ratio Type Table (SRTT) analysis was done between sample and comparison groups. The only LSP subscale which showed a difference between students who were successful and those who were not was spatial ability. Canonical correlation showed that the SLP and the MBTI were related at a level of 0.5 for the first canonical variate. Recommendations for course improvement are suggested. The materials of Biology 110, instruments administration, the MBTI scoring program, and statistical results are appended. (Author/YP)

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COGNITIVE PROCESSES IN THE CURRY LEARNING STYLE FRAMEWORK AS MEASURED BY THE LEARNING STYLE PROFILE AND THE MYERS-BRIGGS TYPE INDICATOR AMONG NON-MAJORS IN COLLEGE BIOLOGY

DISSERTATION

Presented in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in the
Graduate School of The Ohio State University

By

Claudia Tarver Melear, B.S., M.Ed.

* * * * *

The Ohio State University

1989

Dissertation Committee:

R. W. Fortner

P. E. Blosser

M. W. Graham

R. V. Skavaril

A. L. White

Approved by

Rosanne W. Fortner

Advisor
College of Education

SE 051 050

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By

Claudia T. Melear, Ph.D.

The Ohio State University, 1989

Professor Rosanne W. Fortner, Adviser

Curry's (1983) model of learning style framework with Claxton & Murrell's (1987) adaptations was used to study the profile of the non-major in a college biology course. The purpose of the study was to provide empirically derived data in both a qualitative and quantitative format of the non-major (both successful and unsuccessful students) to improve the course. Over 600 students were administered the Learning Style Profile [(LSP) (National Association of Secondary School Principals) (NASSP) and the Myers-Briggs Type Indicator (MBTI) (Consulting Psychologists Press)] to determine the students' learning styles as a predictor for success in the course. The MBTI data were compared to published (McCaulley, 1977) profiles of other populations: biology majors, science majors and biologists. Using a logit model, Introversion (I) and spatial ability predict success with a probability of 0.67 (p<.0005). The profile of the male non-major in biology which is most different from male science majors, by MBTI profile, is ESFP (Extroverted, Sensing, Feeling, and Perceiving) ($p<.001$). ESFPs and ENTPs occur more frequently among unsuccessful students ($p<.001$). ISTJs ($p<.05$) and ISFPs ($p<.01$) occur more frequently among successful students. INTJs and INFPs are more numerous among both biology majors and biologists than among non-majors. Students who are most likely to score below 60% on the computer-managed testing system are E__P (Extroverted and Perceiving)($p<.001$). The only LSP subscale which showed a difference between students sho were successful and those who were not was spatial ability ($p<.01$). A three-factor interaction ($p<.05$) was observed when amount of analytic skill, question type (low, high, and image), and correct vs incorrect answers were submitted to an ANOVA on 96 students and six questions. Items which measure analytic ability were classified as spatial ability items. A 9 factor varimax rotation factor analysis for the LSP established the six item analytic scale. Canonical correlation shows that the LSP and the MBTI are related at a level of 0.5 for the first canonical variate, with verbal risk contributing most to the relationship between the LSP and the MBTI, with an explained variance of 24%. Recommendations for course improvement, following the McComb (1985) Instructional Systems Design (ISD) model include providing: opportunities for discussion, for "hands-on" experiences to concretize abstract concepts

which may require spatial ability, less reliance on recall of memorized information, less than 92% of the course evaluation on the computer (multiple choice items). Other recommendations include providing remediation in some skills, such as analytic and spatial.

Dedicated to the people who taught me most
about the thing that matters most:

Hewitt C. Gehres

and

My children, Nathan and Kelly

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VITA

December 1, 1942	Born, Atlanta, Georgia
1975	A.A., Clayton Junior College, Morrow, Georgia
1977	B.S, Georgia State University, Atlanta, Georgia
1984	M.Ed., Georgia State University, Atlanta, Georgia
1978-85	Biology Teacher and Teacher of Gifted, M.D. Collins High School, College Park, Georgia
1986	Teaching Associate, Science Education, The Ohio State University
1986-88	Research Associate, Instruction and Research Computing Center, The Ohio State University
1988-89	Teaching and Research Associate General Biology, The Ohio State University

PUBLICATIONS

Melear, Claudia T. (1988). Perceptions of Research Scientists and Science Educators Regarding Science Education: Call for Synergy. *NARST Abstracts and ERIC*. ED 294737.23p.

Melear, Claudia T. (1986). Creative Science Teaching. In D. DeLuca (Ed.), *Proceedings of Creativity and Science*

Conference. Hawaii Council of Teachers of English, Honolulu, pp. 242-246.

Melear, Claudia T. (1986). "Organizing Community Support for Your Science Program," Georgia Science Teacher, 25 (3): 2-3.

Melear, Claudia T. & Linda Bostick (1985). "Mucking About," The Science Teacher, 52 (7):32-33.

Alexander, Gretchen M.; Goodson, Phyllis; Hanneman, Patricia J.; Melear, Claudia T; Contributor to Teacher's Edition, 1985. Biology. Scott, Foresman and Company, Glenview, Illinois (Sleznick, et al.).

Melear, Claudia T. (1984). "Science Teaching Insights: A Laboratory Aide Training Program." The American Biology Teacher, 46 (2):81-6.

FIELDS OF STUDY

Studies in Science Education:	Professor Patricia E. Blosser Professor Rosanne W. Fortner Professor Mildred W. Graham Professor Arthur L. White
Studies in Biology:	Professor Russell V. Skavaril
Studies in Computing and Educational Research:	Professor Russell V. Skavaril Professor Arthur L. White

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CHAPTER I

INTRODUCTION

IMPORTANCE OF THE STUDY

For many years, science educators have desired the development of a scientifically literate populace (Fensham, 1987; Flannery, 1987; Gabel, 1976; Hurd, 1986; Walberg, 1983; Yager, 1986). However, there is doubt that the United States has the ability to meet the needs of producing a general work force possessing basic knowledge and skills in the sciences and mathematics (Bloch, 1987).

The magnitude of the problem was indicated by Jon Miller, who reported at the 1989 meeting of the American Association for the Advancement of Science (AAAS) that only 6% of U.S. adults possess the level of understanding of science and technology needed to function minimally as citizens and consumers. According to Miller, only one in 18 adults has enough vocabulary and understanding of scientific concepts to make informed decisions on such issues as nuclear power and genetic engineering. He continued with "... it is the college science experience that makes a difference..." in adult scientific literacy (p. 21). It is therefore imperative that such courses serve their populations effectively and efficiently.

All students do not go to college. Of those who do, not all major in science. However, as a part of their basic education as an undergraduate, students are required to elect a science course.

Improving college science courses for the non-major could result in better prepared teachers and better precollege education. Bloch (1987) and Gardner (1985) both call on college teachers to take the lead in improving science education at the pre-college level, but neither of them say how that is to be done. Teachers at the pre- college level are dependent on college science teachers for their understanding of science. Elementary and middle school teachers may take classes in the non-major sections in science during their undergraduate years. Therefore, improvements in the courses for non-majors would directly affect this population, who will in turn encourage future scientists. Thus, indirectly, improvement in courses for the non-major will affect graduate school education in the sciences. Bloch suggests that current reward systems are at fault: there are no rewards in academic science for spending time improving undergraduate non-major courses.

Anything that scientists can do to improve instruction for the non-major in science would be a great step towards improving science education. Improvement in the courses for the non-major could improve literacy for large numbers of citizens. (Chapter two includes a review of undergraduate courses for the non-major in biology.)

Westheimer (1987) writes that, though scientists do not really want to teach the "unwashed" (meaning the non-major), special courses in science for non-majors probably are needed. He writes about the invention and reinvention of many of these courses for non-majors in biology across the country; such courses are difficult to design and frequently fail in their purpose. Westheimer speaks eloquently of the need for the individuals who populate these courses to learn some substantive science - the legislators, the educators, the lawyers and judges, and the business executives of the future in America.

Yet there is evidence that courses in science for the non-science major may not be meeting the needs of their students. The evidence is fragmented; however, indicators of segments of possible problems are stated by Robb ("G E's Walter Robb," 1989). Robb says that improvement in undergraduate courses for all students is needed, because even at the sophomore level, students continue to drop out of science as a major, even though they have come that far and still have an interest in chemistry or another scientific discipline. Perhaps knowing more about the students in a college science course can help instructors meet student needs and thus improve achievement (Carrier & Jonassen, 1988).

STATEMENT OF PURPOSE

The purpose of the study was to gather data on learning styles of students enrolled in a biology course for non-majors for possible redesign and improvement of the course.

DEFINITIONS OF TERMS

Biology 110 - a one quarter biology course for non-major undergraduate students. The course descriptions can be observed in Appendices A-E. An acronym (NMBC) for the course has been developed and will be used throughout the dissertation. (See non-majors biology course.)

Cognitive process - something that the learner does that has traditionally been called "thinking." A cognitive process is something the learner does with information after it is presented. Examples include sequential processing, categorization, memory, etc.

Cognitive science - the interdisciplinary study of how people acquire and process information and how the human mind represents information.

Cognitive style - that part of the learning style paradigm which constitutes cognitive process activity.

Learning style - the National Association for Secondary School Principals (NASSP) Task Force has defined learning style as "the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment." (Keefe et al., 1986). Learning style is measured in this study by both the Learning Style Profile (LSP) and the Myers-Briggs Type Indicator (MBTI).

Metacognition - cognition about cognition; thinking about thinking, or in the case of metalearning - learning about learning.

Myers-Briggs Type Indicator (MBTI)- an instrument to describe a person's personality, based on the psychological type theory of Jung.

Non-major biology course (NMBC) - See Biology 110.

Perceptual modality - see sensory modality.

Psychological type - a term defined by Carl Jung (1921) which describes fundamental differences among individuals. In this study the term is used synonymously with personality and is measured by the MBTI.

Sensory modality - also called perceptual modality. A first hand preference expressed by a learner for instructional delivery, across domains of learning. It is not usually content specific, as in "biology perceptual modality," but is a generic type of descriptor, used by an individual, to describe preference for learning - either visually, auditorially, emotively, or bodily- kinesthetically.

PROBLEM STATEMENT

The literature on scientific literacy contains great emphasis on knowledge for personal use, such as environmental problems, societal issues(e.g. genetic engineering), and use of nuclear power. However, biology courses for non-majors often emphasize accumulation of biological facts, rather than scientific literacy outcomes. These courses often provide a stringently defined delivery format with a single type of assessment measure (i.e., multiple choice questions delivered by the computer).

The problem for scientists who design courses for non-science majors is that the biologists generally do not have data which quantitatively define the non-biology majors. Furthermore, the biologists who design the courses do not have data which qualitatively describe a learning environment that would promote scientific literacy. Therefore, the focus of the study was to provide data related to learning style, and learning environments which could suggest changes in the courses to more appropriately provide for the non-major.

BACKGROUND OF THE PROJECT

An extensive needs analysis was begun at a major midwestern university in late 1986 to evaluate the introductory non-major biology course (NMBC), in terms of where revision/improvement efforts should be directed. The course had apparently not been evaluated since its inception in 1969. The instructional design model of business and industry has been followed in planning for implementation of modern instructional technologies (Coldeway and Coldeway, 1987; Dodge, 1987; Kearsley, 1984; Mager, 1984). These models utilize learner characteristics to design modular instruction for training.

INSTRUCTIONAL SYSTEMS DESIGN

If the NMBC course is seen as an instructional system to be redesigned, there are well established models to follow. A review by McCombs (1986) describes the model used by business and industry as instructional systems design (ISD) and lists its many steps for successful instructional program design. The generic steps for ISD are:

-needs assessment

-specification of broad goals and detailed objectives of learning outcomes

-development of criterion-referenced tests for assessing goals and objectives

-analysis of goals and objectives to determine types and sequencing of skills
-analysis of learner characteristics
-specification of instructional strategies based on task and learner analysis
-selection of media to implement strategies
-development of courseware based on strategies and media selected
-formative evaluation and revision of materials
-installation and maintenance of programs

McCombs (1986) states that early examples of the ISD model are self-paced or individualized instruction, usually in the form of programmed texts. She states that more cognitively oriented approaches to steps in the ISD model have now evolved. She states that while behaviorism and the focus on outer behaviors formed the earlier theory of ISD, current theories of learning have evolved away from the external behavioral focus to a focus on internal perceptions, cognitions, and motivations. These internal foci compose the cognitively oriented approaches in today's ISD.

Dick argues, in McCombs (1986), that the most difficult phase of the ISD model is the "front end analysis"; that is, the analysis which includes learner characteristics, task analysis, heirarchical analysis, and job analysis. Dick continues,

> ... there is growing recognition that, first, the analysis of instructional requirements must include an understanding of the role of the learner and the teacher in the overall learning process. Second, the analysis process must include an understanding of how knowledge is organized in students' minds and the role of knowledge in different stages of learning. Third, analysis procedures must include a total systems perspective, wherein not only learning tasks and learner characteristics are analyzed, but where learning environments and social contexts are analyzed as well. (p.72)

This study utilized portions of the ISD approach - the analysis of the learning characteristics of the non-major. It also examined the learning environments and social contexts in the sense of describing the sites of the learning events and the preferences stated by the students for learning. Learning style measurements of fundamental perceptions and motivation were also obtained.

Carrier & Jonassen (1988) write that:

> Instructional designers, like other educators, profess the importance of attending to the characteristics of the learners. The Andrews & Goodson (1980) review of some forty instructional design models revealed that most advocate some form of target population analysis. For the most part, however, individual models do not present a strong rationale for assessing particular learner characteristics, nor do they prescribe how this information, once gained, might be used by designers of instructional products. Some models advocate the collection of information about general characteristics such as general ability or attitudes, while many recommend that prior knowledge be assessed. Guidance on how to incorporate knowledge about learners is typically sparse and often a statement of the obvious.(p.73)

Carrier & Jonassen continue with the rationale for the importance of pursuing identification of learner characteristics because of microcomputing technologies,

> Increasingly, microcomputer environments are becoming multimodal. That is, they can present information in multiple channels, including auditory, visual, and tactile. . . The first problem is our incomplete understanding of the learner. . . Second, knowing how learner characteristics interact with instructional treatments provides the basis for prescribing adaptive treatments. . . Third, we need to provide empirically verified prescriptions`about (or a model for) how to design instructional treatments that accommodate individual differences. (p. 73, 1988)

Claxton & Murrell (1987) write that, in higher education, an important question to be asked of any instructional strategy is whether that effort is consistent with the learning styles of the students concerned. Consistent with 1.) the importance in instructional design to match new technology capability and 2.) the cognitive science emphasis in science education, the need to gather learning style data became apparent as a part of the needs analysis for the NMBC. Although there was a large amount of literature available on pre-college education regarding learning style, it was not until 1987 that support of this approach in higher education was evident through the work of Claxton & Murrell.

In the case of the NMBC, learner characteristics in the form of learning style variables have been identified and students' performance in the course has been correlated with their learning styles. These data are available to form the baseline for experimental studies when, or if, new teaching formats are implemented.

COGNITIVE SCIENCE OR COGNITIVE PROCESS APPROACH

The learning style approach is emerging from cognitive process identification in learners (Henson, 1984). In contrast to Piaget (1972), who discussed developmental levels as prerequisites for curriculum design, and to the behaviorist tradition of B.F. Skinner, this study uses the cognitive science approach.

Champagne & Hornig (1987) state that there are two forms of cognitive science: information processing and constructivism. The information processing approach is older and passive, similar to comparing a learner's brain to a computer in which data are manipulated. In the information processing approach, the emphasis is on the things going into the learner's brain, the "input" and on the things coming out of the learner's brain, the "output." The constructivists focus on what happens inside the learner after information is "input," rather than on the actual structure of the "input" or analysis of the "output." Constructivists seek to actively engage the learner in meaningful learning. The constructivists direct attention to the step between input and output of information, the "cognitive process." diSessa and Ploger (1987) write that the cognitive approach to science education is a rather recent event and that truly useful interactions between cognition and science education have occurred for less than ten years.

The constructivists focus on the condition within the learner, which involves several concepts, one of which is metacognition. Another is prior knowledge, but since this study did not assess prior knowledge as a condition for current achievement, only the metacognitive aspects of constructivism will be discussed. While Ausubelian theory stresses prior knowledge as a prerequisite for meaningful learning, learning style theorists suggest that an equally valid prerequisite for learning to occur, meaningful or rote, is a learner's preference for learning conditions (Keefe, 1988, & Dunn, 1984), which could be called "prior preference." These "prior preferences" could be in the way the learner prefers information to be presented, or could be preferences in the social and environmental milieu of the class situation.

The NMBC was built on the behaviorist tradition of B. F. Skinner, whose technology of teaching drove programmed instruction. The NMBC utilizes a form of modularized programmed instruction known as the audiotutorial approach which was developed by Postlethwaite (Postlethwaite, Novak, & Murray, 1972). Behavioral objectives are the foci for learning. The NMBC has very little variation on the one theme: recall of information presented on an audiotape.

RELATED LITERATURE

Douglass (1979) has shown that students' achievement in three units (genetics, evolution, and mitosis) within a high school biology course was significantly higher when instruction was presented in each student's preferred learning style. Reviews by Claxton & Murrell (1987) and Dunn (1980 and 1984) on pre-college learning style are replete with examples indicating that when instruction is matched to learners' preferred learning modes, motivation, and achievement increase.

Designing instruction at the college level based on learning style profiles has rarely been done and never for an entire course. While previous studies have examined up to 1200 post high school vocational students (Gable, 1986), a college population such as students in a NMBC has not been so characterized. However, some data exist on the learning preferences of college students by the personality component of learning style. Roberts (1982) surveyed community college first quarter freshmen to determine their most and least preferred instructional methods. Roberts found that the majority of students (14 out of 16 personality types classified by the Myers-Briggs Type Indicator) least preferred audio instruction when given these choices: audio, demonstrations, diagrams, discussions, field trips, labs, lectures, motion pictures, pictures/slides, programmed instruction, readings, small group work, symbols, and tutorials (Table 1).

Tobias (1982) has stated that instructional strategies and methods do not make a difference in student learning; rather it is the macroprocesses, or cognitive processes engaged by the instruction,which make a difference. She says that when one instructional strategy is demonstrated to make a difference, it is not because of the different strategy, but because it engages a specific cognitive process. Moreover, when two or more instructional strategies are shown to be equal in student achievement, it is probably because the two strategies engage the same cognitive process. In order to determine if Tobias's claim is correct, two things must be done. One is to measure student cognitive processes; another is to analyze cognitive processes required for achievement and compare those elements. Both were attempted in this study.

THE LEARNING STYLE PROFILE

The Learning Style Profile measures learning style in three domains: cognitive, affective, and physiological/environmental. It was the only instrument found by this researcher that attempted to measure cognitive processes in addition to affective and physiological/environmental preferences, all of which are described by Keefe (in Henson, 1984) as important dimensions of learning style. An amplification

TABLE 1.1

MOST PREFERRED AND LEAST PREFERRED MEDIA OF EACH PERSONALITY TYPE AMONG 335 FIRST-TERM COMMUNITY COLLEGE FRESHMEN

ISTJ N=27(8.1%) Labs Demonstrations *Lectures* *Audio*	ISFJ N=31(9.2%) Discussions Tutorials *Symbols* *Audio*	INFJ N=7(2.1%) Tutorials Pictures/Slides *Symbols* *Audio*	INTJ N=9(2.7%) Readings Tutorials *Field Trips* *Audio*
ISTP N=14(4.2%) Demonstrations Labs *Audio* *Discussions*	ISFP N=26(7.8%) Demonstrations Role Playing Labs *Discussions* *Lectures*	INFP N=16(4.8%) Discussions Lectures Readings *Audio* *Motion Pictures*	INTP N=11(3.3%) Tutorials Readings *Audio* *Small Group Work*
ESTP N=19(5.7%) Demonstrations Role Playing Motion Pictures/TV *Audio* *Programmed Instruction*	ESFP N=32(10.0%) Small Group Work Motion Pictures/TV *Programmed Instruction* *Readings*	ENFP N=11(3.3%) Small Group Work Discussions Readings *Symbols* *Diagrams* *Audio*	ENTP N=6(1.8%) Discussions Readings *Audio* *Demonstrations* *Role Playing*
ESTJ N=51(15.2%) Lectures Labs Demonstrations *Audio* *Small Group Work*	ESFJ N=46(13.7%) Labs Tutorials *Audio* *Lectures*	ENFJ N=15(4.5%) Readings Field Trips *Audio* *Discussions*	ENTJ N=14(4.2%) Demonstrations Readings *Discussions* *Audio*

Note: Most preferred media are in regular type.
Least preferred media are in italics.

Roberts (1982)

of the tri-dimensional model of Keefe was used in this study: the multi-dimensional model of learning style by Curry (1983), with an adaptation by Claxton & Murrell (1987). (See Figure 1 for a diagram of the Curry model with Claxton & Murrell's adaptation.)

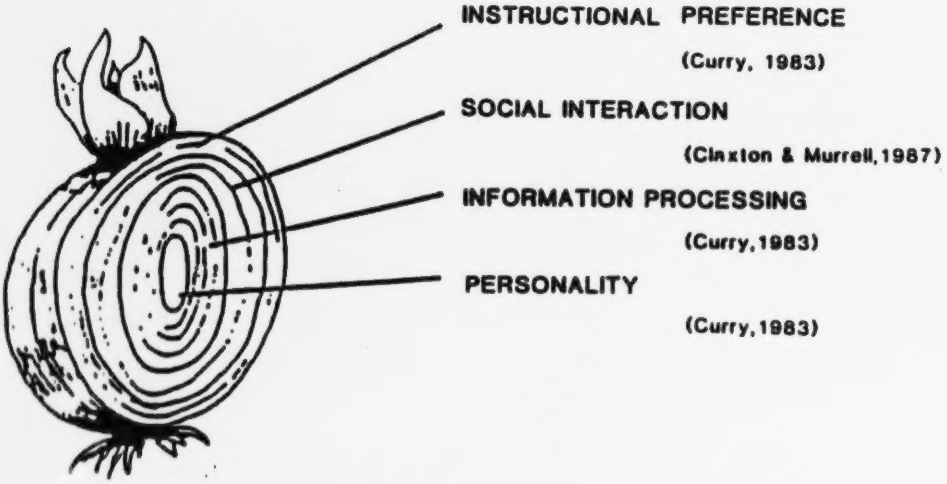
INSTRUCTIONAL PREFERENCE
(Curry, 1983)
SOCIAL INTERACTION
(Claxton & Murrell,1987)
INFORMATION PROCESSING
(Curry,1983)
PERSONALITY
(Curry,1983)

Figure 1. Learning Style Framework

THE CURRY FRAMEWORK OF LEARNING STYLE

Curry (1983) writes that a technical reorganization of learning style constructs is needed in order to find an empirically testable model, a model with established psychometric standards. She cites the confusion that abounds in the literature regarding definitions and conceptualization of the learning style idea. This confusion has impeded progress in the use of the learning style paradigm, if there is such a paradigm. Curry has organized various studies into a framework that she presents as a testable model. Curry's model, presented here, is used in this study because data from all of the layers of the onion model contain variables collected by either the Learning Style Profile or the Myers-Briggs Type Indicator in this study. Table 2 lists Curry's components of learning style and the various members of each of her components as collected by instruments used in this study. Table 2 also lists components of learning style according to Claxton & Murrell (1987).

INSTRUMENTS TO MEASURE THE CURRY DIMENSIONS OF LEARNING STYLE

One instrument used in this study to measure learning style was the Learning Style Profile (LSP) produced by the National Association of Secondary School Principals (Keefe, Monk, Letteri, Languis, & Dunn, 1986). The LSP measures the two outer layers of the Curry model and the social interaction layer of the Claxton & Murrell Model. The other instrument used in this study was the Myers-Briggs Type Indicator (Consulting Psychologists Press, 1987) which measures the personality dimension of learning style, the inner layer or "core" of the onion model.

TABLE 2
FRAMEWORKS FOR LEARNING STYLE HYPOTHESIZED AND TESTED

Curry's	Claxton & Murrell's Components (1983)	LSP & MBTI* Components (1987)
Cognitive Personality Style	Personality	MBTI Analytic Spatial
Information Processing Style	Information Processing	Discrimination Categorization Sequential Processing Memory
	Social Interaction	Grouping Mobility Posture
Instructional Format	Instructional Preference	Visual Auditory Manipulative Study Time Verbal-Spatial Posture Sound Lighting Temperature

*LSP=Learning Style Profile
MBTI=Myers Briggs Type Indicator

HYPOTHESES

1. Psychological types of non-majors in biology are different from those of majors in biology.

Null: There is no difference in the distributionof psychological types, as measured by the Myers-Briggs Type Indicator, among the non-majors in Biology 110 and among student majors in biology (McCaulley, 1977).

2. Non-majors in biology have different psychological types than majors in science.

Null: There is no difference in the distribution of psychological types, as measured by the Myers-Briggs Type Indicator, among the non-majors in Biology 110 and science student majors (McCaulley, 1977).

3. Non-majors in biology have different psychological types than biologists.

Null: There is no difference among the distribution of psychological types among non-majors in biology and biologists (CAPT Atlas of Type Tables).

4. Students who are successful in biology, as defined by achieving a final cumulative test score on the computer-

managed testing system of 60 or greater, have different learning styles than students who are not successful.

Null: 4.a) There is no difference in the distribution of psychological types, as measured by the Myers-Briggs Type Indicator, among the students who score 60 or greater on the computer-managed testing system and the students who score less than 60.

Null: 4b.) There is no difference in the mean scores of learning style, as measured by the 23 subscales of the Learning Style Profile, among students whose final cumulative test score is 60 or greater and among students whose final cumulative test score is less than 60.

5. Cognitive processing skills, as measured by the Learning Style Profile, will predict student ability to answer questions which demand that skill.

Null: There is no relationship between a student's score in cognitive processing skills, as measured by the Learning Style Profile, and the student's score on questions which are perceived to demand that skill.

6. The Myers-Briggs Type Indicator, as the personality component of learning style according to Curry (1983), predicts information processing and instructional format (portions of the Curry model) as measured by the Learning Style Profile.

Null: There is no predictive ability of the Myers-Briggs Type Indicator towards information processing or instructional format.

ASSUMPTIONS

The following assumptions underlie the study:

1. Students were honest and conscientious in completing the instruments.
2. The constructs targeted for measurement by the instruments are fundamental to learning and can inform instruction in biology.
3. Administration of the MBTI as a take-home assessment did not bias the results of the study.

DELIMITATIONS

1. The study was limited to those students enrolled in General Biology 110 at The Ohio State University Winter Quarter, 1988.

2. Testing was completed within one class period for the Learning Style Profile and one week for the Myers- Briggs Type Indicator.

LIMITATIONS

1. The instruments used to detect learning styles are self-report pencil and paper measures.

2. The population of Biology 110 is self-selected; i.e., students select Biology 110 as either an elective or, usually, because their college major requires a five hour science course.

3. The gathering of learning style information was restricted to two instruments.

4. The Learning Style Profile has not been normed on an adult population.

5. The comparative populations may have differed in ways not known to the researcher.

OVERVIEW

This dissertation includes five chapters.

Chapter One provides a rationale for the study, including importance of the study, statement of the problem, problem statement, and background of the project. Also included in Chapter One are hypotheses, assumptions, delimitations, and limitations.

Chapter Two contains a review of the literature and is reported in three sections. The sections cover the status of science education at the undergraduate level for non-majors, learning style importance in higher education, and studies in science and in higher education which have used the learning style approach. Chapter two includes work of other MBTI researchers, some of which describes the learning style preferences by psychological type.

Chapter Three consists of the research design and procedures. They address the overall design of the project, background of data collection, data collection procedures, and statistical analysis procedures.

Chapter Four presents the study's results. Descriptive statistics are presented for each instrument followed by correlations, regressions, canonical correlations, and factor analysis.

Chapter Five contains a summary, conclusions, implications for course improvement, and recommendations for future research, based on the findings.

CHAPTER II

REVIEW OF THE LITERATURE

The literature reviewed for this section will be presented under the following headings:

(1) The Status of Undergraduate Science Education
(2) Learning Style Importance in Education
(3) Studies in Science and in Higher Education in Which the Learning Style Approach was Used
(4) Summary

THE STATUS OF UNDERGRADUATE SCIENCE EDUCATION

An implicit goal of biology courses for non-majors in college is scientific literacy (Meleca, 1973; Skavaril, personal communication). It is understood that any such course is likely to be the students' only (or last) exposure to formal science learning. Peterson & Jungck (1988) believe that "an unrealistic approach to science learning has metastasized throughout biology courses" at the undergraduate level (p. 14). They report that textbooks are dry and static, lectures push information to students who have become junkies for mythical 'scientific facts'" (1988, p. 14).

The "metastasis" that Peterson & Jungk identify has occurred between the systems of higher and pre-college education, according to some. Dykstra (1987) and Cronin, Charron & Espinet (1987) state that biology education in colleges today, especially in science classes for non-major undergraduates, differs little in the character, flavor, and emphasis on factual information, from the data on pre-college science presented in the comprehensive Project Synthesis (Harms & Yager 1981). Project Synthesis reported that the curriculum in science classes is 90 percent one textbook alone: instruction is predominantly by the lecture method. Hurd writes, in the biology education portion of Project Synthesis, that "an analysis of existing programs at the secondary level (middle/junior high and senior high school) reveals that discrete knowledge, in and of itself, continues to be the emphasis of all programs" (1981, p. 22). He continues, "the emphasis has been on vocabulary and narrow course objectives," (p. 20) that goals for teaching science for the majority of states were "facts, concepts, principles." (1981, p. 20). Further, (p.20) "Compared with acquiring information, all other educational goals are seen as of minor importance."

Blystone (1987) reports, in fact, that the greatest overall threat to science education is the temptation to be current in the content of modern college introductory biology textbooks. Textbooks become larger and larger every year; in the 1950s, the average was around 600 pages; in the 1980s, around 1200 pages. Blystone says that students are bombarded by endless scientific terms that have little appeal to non-science majors. Wivagg (1987) states that, in effect, we have a national biology curriculum because of a lack of diversity in textbooks. The national curriculum exists in the monolithic encyclopedic biology textbooks that freshmen undergraduates are presented for a one-quarter course of study.

UNDERGRADUATE COURSES FOR THE NON-MAJOR IN BIOLOGY

As stated in chapter one, Westheimer (1987) writes that courses for the non-major in biology are invented and re-invented. He cites the need to focus on the very groups that probably, according to McCaulley (1977), outnumber scientists at the ballot box and in the legislature - the educators, lawyers, and judges and the business executives of the future. The difficulty in designing courses for non-majors lies in differences between these science non- majors and science majors in motivation, interest, and learning style (McCaulley, 1977). McCaulley states that differences in science majors and non-science majors are not in learning aptitude or intelligence.

Carlson (1981) writes that it is clear that biological education for non-majors has failed to meet the general public's need for knowledge. He says that "Potential leaders benefit little from the standard course for non- science majors...abstract principles of nucleic acid chemistry, Mendelian laws, mitotic divisions...are remote and quickly forgotten by students if they are not...tied to students' experience" (1981, p. 440). Recommendations from Carlson indicate that both content and presentation format need to be reformed. For instance, at large universities, where there are separate courses for the science major and the non-science major, the content of the course for the major is usually departmentally mandated, whereas the content of courses for the non-science majors may be of little concern to the biology department. Faculty members who teach the non-majors course may be assigned to these courses as a punishment for poor scholarly productivity (Carlson, 1981).

Carlson continues,

> The course is usually out of favor with the rest of the faculty, who perceive nonmajors as lacking the capabilities and enthusiasm that biology majors (have)... Yet few biology majors will be among the lawyers, business executives, legislators, ministers, consumer activists, and journalists who will shape and decide the values and laws that govern the applications of biology to the individual and society, (1981, p.441).

Carlson is not proposing that learning opportunities for non-majors be individualized or small group in large universities; he acknowledges the fiscal reasons for large lecture formats. Yet he states that opportunities should be provided for students to discuss the material they are trying to learn. He suggests that undergraduate students, rather than graduate students in biology, be trained to be teaching assistants for college credit. He has designed such a program in his setting and he describes how it works. The basic idea is that students who are motivated by receiving college credit for being a teaching assistant, rather than students who are amotivated (graduate students in biology), take an interest in providing one-hour discussion sections with twenty or fewer students. They tutor and go over notebooks which are required.

Carlson emphasizes the need to differentiate the learning environment between the introductory courses for the majors and for the non-majors. The nonmajors, he says, "would clearly suffer in a course that . . . places a heavy emphasis on problem-solving activities" (1981, p. 449).

Dean (1978) lists several principles that are important in considering working with nonmajors in biology. 1.) nonmajors are not, by definition, less able than majors. 2.) Nonmajors forced to take biology against their will often lack motivation. 3.) The course for nonmajors should not consist of an introduction to courses they will never take. 4.) No one can "cover" biology in a quarter, semester, or year. 5.) The relationship of biology to the concerns of the students as human beings, citizens, and thinking people must be more explicitly addressed than in other biology courses. 6.) The population in classes for non-majors is likely to be more diverse in ability than in classes for majors. 7.) "Facts are not enough" (1978, p. 565).

In summary, the writings of Westheimer, Carlson, and Dean give a clear picture that teaching non-majors in biology is difficult, costly, and different than teaching majors. All of them point out the importance of recognizing the future jobs of the non-majors and the ultimate importance of this group in affecting scientific literacy for the citizens and in affecting legislation about scientific issues. The need for opportunities to interact among the students was emphasized by Carlson.

LEARNING STYLE IMPORTANCE IN EDUCATION

Claxton & Murrell (1987) produced a succinct review of the use of learning style in college teaching. They wrote that, though the idea of learning style may draw the attention of faculty and administrators in a compelling way, learning style has not yet significantly affected educational practices in higher education for many reasons. Some reasons are that 1.) Different writers use the word "style" to mean different things 2.) Higher education emphasizes research in the disciplines rather than the teaching and learning of those disciplines and 3.) The concepts of issues surrounding learning style are poorly framed and the characteristics associated with it are difficult to assess. (1987, p.1).

Claxton & Murrell (1987, p.1) cite Curry's onion model (Figure 1 and 2) as a framework which is useful to describe learning style. Curry's model is used in this study because all of the layers of the onion model, which represent various aspects of learning style, are measured by instruments used in this study. The "outer layers of the onion" (instructional format, information processing, and, for the Claxton & Murrell adaptation, social interaction) are measured by the Learning Style Profile (LSP). The "core of the onion" (personality) is measured by the Myers-Briggs Type Indicator. Curry's framework for learning style organization is based upon internal consistency scores of tests which measure learning style components. She says that tests which measure personality, such as the Myers-Briggs Type Indicator and Witkin's Embedded Figures Test, have higher internal consistencies than tests which measure information processing or environmental components. Curry examined 40 tests which measure components of learning style to determine which tests had highest internal consistencies. She then organized the tests by the three components in the model: personality, information processing, and instructional format.

Claxton & Murrell, as well as Curry, describe the Myers-Briggs Type Indicator as an example of the personality model portion of learning style, the core of the onion model. The description of the Myer-Briggs Type Indicator (MBTI) which follows is according to Claxton & Murrell.

MYERS-BRIGGS TYPE INDICATOR (MBTI)

The MBTI is an instrument used in applying Jungian theory in education, counseling, and business. Jungian theory states that there is consistency and order in seemingly random variations in behavior when one considers the different ways in which people prefer to take in information (perception) and the ways in which they choose to make decisions (judging function). Jung states that persons can perceive the world in two distinct ways (sensing or intuition) and that people use two distinct and contrasting ways to reach conclusions (thinking or feeling). Jung also describes a person's attitude toward life as judging or perceiving (not to be confused with perception or the judging function). Lastly, Jung describes the way persons direct energy as either being outward (extraversion) or inward (introversion).

Myers and Briggs developed an instrument which measures a person's preferences within the dichotomies described by Jung. The preferences exist on four scales: Extraversion versus Introversion (E-I), Sensing versus Intuition (S-N), Thinking versus Feeling, (T-F) and Judging versus Perceiving (J-P) (Figure 2).

A. The Sixteen Preference Types on the Type Table

	Sensing		Intuition		
Introversion	ISTJ	ISFJ	INFJ	INTJ	Judging
	ISTP	ISFP	INFP	INTP	Perception
Extraversion	ESTP	ESFP	ENFP	ENTP	
	ESTJ	ESFJ	ENFJ	ENTJ	Judging
	Thinking	Feeling		Thinking	

B. Location of the Four Scales Within the Type Table

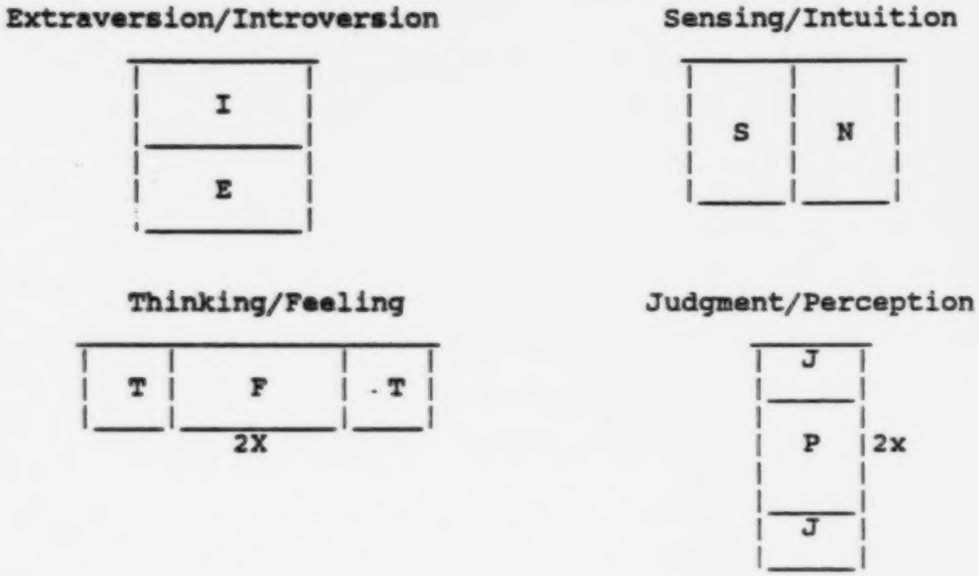
Extraversion/Introversion
I
E
Sensing/Intuition
S
N
Thinking/Feeling
T
F
T
2X
Judgment/Perception
J
P
2x
J

Figure 2. Diagram of the Myers-Briggs Type Table (Gable, 1985)

The E-I scale measures the direction of a person's preference, or energy and interest toward the outer world of persons, actions, and objects (E) or toward the inner world of ideas and concepts (I). The S-N scale measures the person's preference toward perceiving the world through the realities of experience taken in by his or her five senses (S) or for perceiving the world by inferred meanings and possibilities (I).

The T-F scale measures a person's preferences for whether or not s/he relies more on logical order or more on personal values in making judgments. Finally, on the J-P scale, the preferences are characterized by a person's tendency to desire closure by planning and controlling events (J), or by being flexible, waiting to see what happens and by reacting to events with spontaneity (P).

Jensen (1987) (Table 3) presents the relationship of MBTI type and learning style. Claxton & Murrell cite studies that demonstrate a relationship of MBTI profiles and learning styles. For example, in one study by Lawrence, sensing and judging correlated with order, thinking with endurance, introversion with achievement, intuition and perception with autonomy, and feeling with nurturance (p. 14). In another study by Lawrence, perception is linked with tolerance of complexity as well as impulsiveness. Extraversion correlated with talkativeness, sensing with gregariousness and intuition with artistic qualities and liking to use the mind (p.14).

TABLE 3

MBTI
TYPE AND LEARNING STYLES*

Extraversion (E)	Introversion (I)
Es learn best in situations filled with movement, action, and talk. They prefer to learn theories or facts that connect with their experience, and they will usually come to a more thorough understanding of these theories or facts during group discussions or when working on cooperative projects. Es tend to leap into assignments with little "forethought," relying on trial-and-error rather than anticipation to solve problems.	Since Is may be more quiet and less active in the classroom, teachers may feel the need to press them into taking part in group discussions. Such pressure, however, will often only increase their withdrawal. Teachers need to respect their need to think in relative solitude, for that is how they think best. Is will be more willing to share their ideas when given advance notice. This will allow them time to think about how they will become active in the classroom.
Sensory Perception (S)	**Intuitive Perception (N)**
Ss learn best when they move from the concrete to the abstract in a step-by-step progression. They are thus at home with programmed, modular, or computer-assisted learning. They value knowledge that is practical and want to be precise and accurate in their own work. They tend to excel at memorizing facts.	Ns tend to leap to a conceptual understanding of material and may daydream or act-out during drill work or predominately factual lectures. They value quick flashes of insight but are often careless about details. They tend to excel at imaginative tasks and theoretical topics.
Thinking Judgment (T)	**Feeling Judgment (F)**
Ts are most motivated when provided with a logical rationale for each project and when teachers acknowledge and respect their competence. They prefer topics that help them to understand systems or cause-and-effect relationships. Their thought is syllogistic and analytic.	Fs are most motivated when given personal encouragement and when shown the human angle of a topic Fs think to clarify their values and to extablish networks of values. Even when their expressions seem syllogistic, they usually evolve from some personally held belief or value.
Judgment (J)	**Perception (P)**
Js tend to gauge their learning by the completion of tasks: reading "x"-amount of books, writing "x"-amount of papers, or making "x"-amount of reports. They thus prefer more structured learning environments that establish goals for them to meet.	Ps tend to view learning as a free-wheeling, flexible quest. They care less about deadlines and the completion of tasks. They prefer open and spontaneous learning environments and feel "imprisoned" in a highly structured classroom.

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*Jensen (1987)

BEST COPY AVAILABLE

Summaries of studies by Lawrence (1984) are presented in Tables 4, 5 and 6.

McCaulley (1977) writes that Jungian theory can help to explain the differences among the majors and the non- majors in science. She says that MBTI type theory can help explain that some people are "science-minded"; these are the types more likely to enter science. Gable (1985) (Table 7) presents data which show distribution of types within occupational groups. According to Gable's data, research scientists are 100% NT, an indication of which types are "science minded", by McCaulley's definition.

McCaulley says that science types are probably outnumbered at the ballot box and in the legislature and that scientists might feel that society does not appreciate, or even rejects them. On the other hand, she says that type theory can help scientists to understand that for nonscientists, "logic does not speak for itself" and it is not enough "to discover simply for the joy of discovery" (p.117). Thus, there is much that each group can learn about the other to facilitate cooperation and understanding. Campbell's (1986) study (Table 8) determined which learning format was preferred by each MBTI type. These studies indicate that people with different learning styles and personalities prefer different instructional modes.

TABLE 4

LEARNING PREFERENCES ASSOCIATED WITH SINGLE DIMENSIONS OF MBTI TYPE*

Extraversion	Introversion
-talking, discussion -psychomotor activity -working with a group	-reading/verbal reasoning -time for internal processing -working individually
Sensing	**Intuition**
-tasks that call for carefulness, thoroughness and soundness of understanding -going step-by-step -tasks that call for observing specifics -tasks that call for memory of facts -practical interests	-tasks that call for quickness of insight and in seeing relationships -finding own way in new material -tasks that call for grasping general concepts -tasks that call for imagination -intellectual interests (independent of intelligence) -reading
Thinking	**Feeling**
-logical organization of teacher -objective material to study	-personal rapport with teacher -learning through personal relationships
Judging	**Perceiving**
-work in steady, orderly way -formalized instruction -prescribed tasks -drive toward closure, completion	-work in flexible way, follow impulses -informal problem solving -discovery tasks -managing emerging problems

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*Lawrence, G. (1984). A synthesis of learning style research involving the MBTI. Journal of Psychological Type, 8, 2-15.

TABLE 5

LEARNING PREFERENCES ASSOCIATED WITH
MBTI TYPES BY FUNCTION COMBINATIONS

ST Types	**SF Types**
-demonstrations -labs -television -having a plan and sticking to it	-student-led demonstrations or presentations -instruction with personal involvement -television -films and audiovisuals -having a study schedule
NF Types	**NT Types**
-learn through personal relationships -dislike impersonal, didactic instruction -highly value faculty feedback -value student enthusiasm -low-frictionstudent-led discussions -opportunities to be creative and original	-organized teacher lectures -self instruction -reading -systematically organized courses

*Lawrence,G.(1984). A synthesis of learning style research involving the MBTI. Journal of Psychological Type, 8, 2-15.

TABLE 6

LEARNING PREFERENCES ASSOCIATED WITH TWO-LETTER DIMENSIONS OF MBTI TYPES*

ES__ Types

- -reading
- -self-instruction
- -courses that put me on my own initiative
- -working on group projects
- -meeting a lot of people
- -opportunities to be creative and original

EN__ Types

- -television
- -reports to class on topics selected by students
- -scheduling my time
- -having a schedule and sticking to it
- -orderly work on goals set in advance

IS__ Types

- -demonstrations
- -labs
- -computer assisted instruction
- -films, audiovisual aids
- -facts, facts and more facts
- -dislike independent study

IN__ Types

- -serious reading
- -tutorials
- -independent study
- -systematically organized courses

_S_P Types: Structured exploratory observation, hands on

_S_J Types: Structured didactic, sensory rich instruction

_N_P Types: Low structure, inductive instruction

_N_J Types: Moderate to high structure "serious" instruction

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*Lawrence, G. (1984). A synthesis of learning style research involving the MBTI. *Journal of Psychological Type*, *8*, 2-15.

TABLE 7

DISTRIBUTION OF TYPES WITHIN OCCUPATIONAL GROUPS

Occupations	Preferences (%) ST	SF	NF	NT
Accountants	64	23	4	9
Bank Employees	47	24	11	18
Sales, Customer Relations	11	81	8	0
Creative Writers	12	0	65	23
Research Scientists	0	0	23	77
Medical Physicians	34	19	26	21
Dentists	27	23	19	31

Gable (1985). p. 32.

TABLE 8

LEARNER POSTTEST MOST AND LEAST PREFERRED METHODS, TECHNIQUES AND DEVICES BY MBTI DOMINANT FUNCTION GROUPINGS

N = 106

	ESTP N = 3 ESFP N = 0	ISTJ N = 27 ISFJ N = 2	ENTP N = 6 ENFP N = 2	INTJ N = 8 INFJ N = 4	ESTJ N = 19 ENTJ N = 9	ISTP N = 7 INTP N = 12	ESFJ N = 4 ENFJ N = 0	ISFP N = 0 INFP N = 3
				MOST PREFERRED				
1.	CASE STUDY*	DISCUSS WITH INSTRUCTOR	CONFER WITH OTHER STUDENTS*	CONFER WITH OTHER STUDENTS*	GROUP DISCUSSION	GROUP DISCUSSION	GROUP DISCUSSION	DISCUSS WITH INSTRUCTOR*
2.	CONFER WITH OTHER STUDENTS*	GROUP DISCUSSION	GROUP DISCUSSION*	GUEST LECTURER/ SPEAKER*	CONFER WITH OTHER STUDENTS	GUEST LECTURER/ SPEAKER	CONFER WITH OTHER STUDENTS*	GROUP DISCUSSION*
3.	GROUP DISCUSSION*	CONFER WITH OTHER STUDENTS	GROUP PROJECTS*	DISCUSS WITH INSTRUCTOR*	CASE STUDY	DISCUSS WITH INSTRUCTOR	GROUP PROJECTS*	HOMEWORK ASSIGNMENTS*
4.	GROUP PROJECTS*	HOMEWORK ASSIGNMENTS	GUEST LECUTRER/ SPEAKER*	GROUP DISCUSSION*	DISCUSS WITH INSTRUCTOR	CASE STUDY*	GUEST LECTURER/ SPEAKER*	INDEPENDENT STUDY*
5.	GUEST LECTURER/ SPEAKER	BLACKBOARD	N/R	CASE STUDY* DEMONSTRATION* GROUP PROJECTS*	GUEST LECTURER SPEAKER	CONFER WITH OTHER STUDENTS*	N/R	N/R
				LEAST PREFERRED				
1.	ORAL REPORTS*	EXAMINATION	LECTURE*	LECTURE	DRILL AND REPETITION	TERM PAPERS	EXAMINATION	EXAMINATION*
2.	PEER TEACHING*	MEMORIZATION	MEMORIZATION*	MEMORIZATION	MEMORIZATION	ORAL REPORTS	MEMORIZATION	LECTURE*
3.	N/R	TERM PAPERS*	POP QUIZ*	EXAMINATION	POP QUIZ	MEMORIZATION	LECTURE*	LABORATORY
4.	N/R	LECTURE*	DRILL AND REPETITION	DRILL AND REPETITION	TERM PAPERS	GROUP PROJECTS*	POP QUIZ*	MEMORIZATION
5.	N/R	GROUP DISCUSSION* GROUP PROJECTS* POP QUIZ*	GROUP PROJECTS	PEER TEACHING	EXAMINATION	INDEPENDENT STUDY* POP QUIZ*	N/R	N/R

* = INDICATES TIE   N/R = NOT RECORDED

Campbell (1986)

THE LEARNING STYLE PROFILE

The Learning Style Profile was developed by The National Association for Secondary School Principals (NASSP) because of limited instrumentation to measure the wide variety of learning style constructs. The NASSP formed a Task Force to develop the instrument, which became available in 1986. The test was normed on a grade 6-12 population of 5,000 students. The NASSP states in the Examiner's Manual that the LSP is a first-level diagnostic tool. It is recommended to be used with follow-up when results from the LSP may be unclear. The technical manual recommends longer tests which are more reliable than the few items for each construct on the profile. For example, if a student, or groups of students, shows weakness in analytic ability, and analytic ability is a desired skill for a course, the Technical Manual recommends the Embedded Figures Test (EFT), for individual administration to older children, adolescents, and adults. The Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971) is available for group administration to adolescents and adults.

The LSP is a second-generation instrument; i.e., it was created from items which researchers had already found to measure constructs in the learning style domain. The LSP is based on the idea that learning style is composed of cognitive, affective and environmental/physiological elements.

Ferrell (1988) writes that since the LSP is a new instrument, its potential value is still to be documented by its users. She states that no normative data exist for special populations, and such data must be established. She further states that since each learning style subscale is measured by only a few items, that reliabilities and therefore interpretations of results should be approached conservatively. Table 9 lists the subscales and descriptions of subscales measured by the LSP. Figure 3 is a sample LSP computer printout of an individual student.

TABLE 9

LEARNING STYLE PROFILE SUBSCALES (Keefe, 1988)

1. Analytic Skill - the capability of identifying figures concealed in a complex background field.

2. Spatial Skill - assesses two generally recognized components of spatial reasoning: pattern recognititon and spatial rotation.

3. Discrimination Skill - the capacity of focusing attention of the required dimensions of a task and avoiding distractions.

4. Categorization Skill - assesses variations in categorizing behavior.

5. Sequential Processing Skill - refers to a learner's capability or bias for processing information in a step-by- step, linear fashion.

6. Memory Skill - is based on the cognitive style of leveling vs sharpening. Sharpeners show strength in differentiating new information from old; levelers do not.

7. Visual Perceptual Response - characterizes the learner who tends to respond to new information in a visual or pictorial fashion.

8. Auditory Perceptual Response - characterizes the learner who responds to new information in an auditory or listening fashion.

9. Emotive Perceptual Response - characterizes the learner who responds to new information in terms of its feelings.

10. Persistence Orientation - is the willingness to sustain behavior beyond the required time, to withstand discomfort, and to face the prospect of failure.

11. Verbal Risk Orientation - measures a student's willingness to verbalize, to speak out, and to state opinions even if others disagree.

12. Manipulative Preference - characterizes the learner who likes "hands-on" learning activities.

13. Early Morning Study Time Preference (STP) - characterizes preference for studying and learning in the early morning.

14. Late Morning Preference STP - characterizes preference for studying and learning in the late morning.

15. Afternoon Preference STP - characterizes preference for studying and learning in the afternoon.

16. Evening Preference STP - characterizes preference for studying and learning in the evening.

17. Verbal-Spatial Preference - loads with the cognitive factors (1-6) in the factor analysis. This subscale assesses a learner's preference and conceptual orientation for dealing with verbal or spatial tasks.

18. Grouping Preference - measures individual preferences for whole class, small group or dyadic learning groups.

19. Posture Preference - characterizes learner preference for formal or informal study arrangements and related body postures.

20. Mobility Preference - describes learner tendency to move about and take breaks while studying, or to work until the task is finished.

21. Sound Preference - Characterizes variations in reacting to auditory stimulation. Some learners have a need for quiet, while others use moderate background sound as a screen against other distractions.

22. Lighting Preference - describes a learner's need for higher or lower levels of illumination.

23. Temperature Preference - Characterizes a learner's choice to study in a warm or cool setting.

```
               THIS PROFILE IS FOR: Jane Doe

Birthdate: 8/5/00   Sex:  F        Grade:  11      Race:
Date: 2/12/86    School: 0                 Class: 20

     Skills--General approach to processing information

               Score  Weak          Average         Strong
Analytic       52    |________|_______XX|XX_______|________|
Spatial        64    |________|_________|_________|XXXX____|
Discrimination 48    |________|_______XX|XX_______|________|
Categorization 47    |________|__XXXX___|_________|________|
Sequential     57    |________|_________|____XXXX_|________|
Memory         63    |________|_________|_________|XXXX____|

Perceptual responses--initial response to verbal information

               Score  Weak          Average         Strong
Visual         59    |________|_________|_____XXXX|________|
Auditory       41    |________|XXXX_____|_________|________|
Emotive        48    |________|_______XX|XX_______|________|

             Orientationsandpreferences--
    Preferredresponsetostudy or instructional environment

               Score  Weak         Average          Strong
Persistence    54    |________|_________|___XXXX__|________|
Verbal Risk    51    |________|_______XX|XX_______|________|
Manipulative   44    |________|___XXXX__|_________|________|

Study Time:           _____________________________________
Early Morning  45    |________|_________|XXXX_____|________|
Late Morning   40    |________|_______XX|XX_______|________|
Afternoon      50    |________|_________|XXXX_____|________|
Evening        57    |________|_________|_____XXXX|________|

              Score         High     Neutral    High
Verbal-Spatial 52  Spatial|_____|___XX|XX___|______|Verbal
Grouping       31    Small|_____|___XX|XX___|______|Large
Posture        39 Informal|___XX|_____|_____|______|Formal
Mobility       52Stillness|_____|___XX|XX___|______|Movement
Sound          62    Quiet|_____|_____|_____|XX____|Sound
Lighting       34      Dim|_XX__|_____|_____|______|Bright
Temperature    35     Cool|_XX__|_____|_____|______|Warm

Consistency score:  1     Normative sample:  1986 -- National
NASSP--National Association of Secondary School Principals,
Reston, VA
```

Figure 3. Learning Style Profile Computer Printout

STUDIES IN SCIENCE AND IN HIGHER EDUCATION IN WHICH THE LEARNING STYLE APPROACH WAS USED

Gable (1985) states that accountability issues are forcing educators to critically evaluate their programs for effectiveness, efficiency, and excellence. Her study involved a population previously unstudied: health occupation students. Twelve hundred students enrolled in fifteen health occupational fields and three educational settings were administered the Myers-Briggs Type Indicator. Gable found significant differences in the sensing/perception preferences of the health occupation students, between occupational programs and in different educational settings. Further differences occurred in the biographical items. Thus, group membership in various health occupations was significantly predicted by learning style preferences and biographical information. Gable suggests that her findings can be used to improve curriculum design, instructional processes and evaluation procedures.

Daon (1986) studied students enrolled in a BASIC computing course in college. He determined that changes occurred in individual learning styles for the majority of the students during the course. Students engaged in Deep Processing when situational demands became more complex and when they had apparently "automated" low-level computer programming skills. A positive correlational relationship was found between Deep Processing and academic achievement.

Individual background was found to be a determinant in the use of a particular learning style by the student. Learning style processes, identified at entry, were better predictors of success in the course than was (previous) student achievement.

Sharma (1987) reviewed cognitive styles implications for computer science classes. Her examples have implications for other laboratory sciences. She reviewed studies by Tillman (1979), Hoffman and Waters (1982), Bozeman (1978) and Stevens (1983).

Tillman (in Sharma, 1987) suggests a differentiated curriculum: that analytical students be assigned all of their problems for the course on the first day of class and be allowed to progress at their own rate, whereas the heuristic thinkers may require a more structured and formal teaching technique. Analytic problem solvers, according to Sharma, utilize a structured approach to decision-making and attempt to reduce problem situations to a core of underlying causal relationships. Heuristic problem solvers emphasize common sense and intuition, and use the trial-and-error method and feedback to adjust the course of action chosen. Hoffman and Waters' (in Sharma, 1987) work utilized the Myers-Briggs Type Indicator. They suggest varying instruction for the individual student whose profile is Extroverted-Intuitive-Perceiving (EN_P). For example, they suggest instruction with more interaction among students including group work at the computer; use of frequent question-discussion sessions; pop-quizzes to keep learners on task and to promote competition, greater planning and organization of time for learning; and provision for relaxation/quiet times scheduled prior to and during breaks. No significant interaction has been found to occur between personality types and the drop-out rate when this extra amount of attention is given to the students with the Extroverted-Intuitive-Perceiving personality type. The key, according to Sharma, is not to let them get discouraged and fall too far behind.

Sharma cites research of others which shows that analytic thinkers outperform heuristic thinkers in task performance, assuming all other factors are equal. She continues with Stevens' (in Sharma, 1987) observations that field-independent persons had significantly higher scores in instructional computer science courses than field-dependent students. The field-dependent person's perceptions and activities tend to be global and to focus on the total environment, whereas the field-independent subjects' perceptions, on the other hand, are analytical and are not dominated by the prevailing field. Sharma's review includes Bozeman's (in Sharma, 1987) findings that Extroverted-Perceiving (E__P) types overwhelmingly tended to drop out of computer tasks.

Tanenbaum (1981) investigated the relationship between high- and low-structured materials with field dependent or field independent high school students (n=248) in studies in nutrition. She designed the high-structured materials in a logical order using a deductive sequence which required written answers to convergent questions. The low-structure materials presented identical information in a random order which required inductive sequencing and written answers to divergent questions. The experiment tested whether or not achievement of secondary students varied when materials were presented in congruence with their learning style or when the materials were dissonant to it.

Tanenbaum found that field-dependent students achieved significantly higher scores after using the high-structure method; field-independent students achieved significantly higher scores after using the low-structure treatment.

Douglass (1979) determined that, for 3 units, when high school biology students were matched by learning style, and when materials were structured toward their learning style, they were more academically successful in learning biology. Students with strong analytical or strong global thinking strategy benefit the most from instruction geared toward their preference. Douglass's population of students (n=627) was administered a battery of tests to determine their learning style. She was most interested in providing at least one alternative for students who may not process information in a sequential or linear way. Douglass's results showed that materials structured for the analytical or field independent learner enhanced student learning significantly. Moreover, materials structured deductively (globally for the field- dependent learner) enhanced these learners' performance significantly as well. Douglass concluded by stating that, before embarking on a similar journey, teachers must first decide if they are sufficiently committed to individualized instruction to develop two sets of instructional materials for their students.

Kern and Matta (1988) found that intuitive-feeling (NF) students performed less well than did sensing-thinking (ST) students in a computer course. They suggest that sensing-thinking individuals perform better in a self-paced environment and that this performance is consistent with characteristics of their type. The sensing-thinking types prefer working with objective information and pay great attention to detail. They also tend to be better qualified at making decisions regarding the pace and sequence of instruction. Kern and Matta suggest that the intuitive-feeling individual might require some kind of human intervention to supplement the computer environment, by giving this student guidance in the sequencing and pace of instruction.

SUMMARY

The NMBC was initially designed to provide individualized instruction. However, the idea of individualization in 1989 is different than it was in 1969, when the course was designed. Today the idea of individualization is based more on learning style preference than it is on self-paced instruction because some learners have more difficulty than others with regulation of self-pacing. Learning style literature contains evidence that one learning track alone may not reach all the learners. Multiple opportunities may need to be available for pathways through learning materials; multiple levels of support via human interaction may also be needed.

Because institutions of higher education are predominantly consumer-oriented, provisions should be made to give the students instruction in more than one mode to accommodate their learning styles. At the very least, instruction should vary within a course so that learners will have opportunities to learn, at least part of the time, in their preferred mode.

In summary, the literature on learning style and its use in higher education suggests that measuring learning style is a way to begin to recognize and accommodate individual differences in learners. Some literature seems to be directed toward helping students with computer achievement. Computer programming courses may have parallel cognitive demand in analysis and synthesis with introductory science courses, i.e., certain topics must be mastered before others make sense. Sharma's review of Bozeman (1978), Daon (1985), Hoffman & Waters (1982) and the research of Kern & Matta (1988) all present data from studies that used the learning style approach with students. They all say that because of individual differences in student learning styles, teachers need to be more aware that some students may need more support than others to prevent them from dropping the course.

Douglass' and Tanenbaum's studies demonstrate that, when preferred learning style is accommodated, achievement increases. The computer course studies cited in this chapter suggest that the skill-building and orderliness of progression with detail requirements may not have been a workable mode for students who possessed certain learning styles.

CHAPTER III

RESEARCH DESIGN AND PROCEDURES

This chapter is organized into five sections:

1. Overall design.
2. Description of Biology 110, the non-majors biology course (NMBC).
3. Identification of student learning style, which includes the methodology used for part one of the study. Descriptions of the two instruments, Learning Style Profile (LSP) and Myers-Briggs Type Indicator (MBTI) are included in section three.
4. Formation, structure, and organization of the three data bases from which the results were gathered.
5. Statistical procedures used in the data analysis

OVERALL DESIGN

An extensive needs analysis was begun in late 1986 to evaluate an introductory biology course for non-majors at The Ohio State University. Factors reviewed, external to this study, included Bio-Learning Center use, recitation attendance, and examination of modular units of instruction in the computer-managed test system.

To begin a portion of the needs analysis two things were done by this researcher: one, the modular units were examined to determine the unit in which students were having the most difficulty (the unit with the lowest mean score). Two, informal interviews with former students determined that some students loved the course while others hated it. A high drop out, withdrawal, and failure rate exists in the course; approximately 20-25% of the students who enroll and take at least one unit test do not successfully complete the course. The research design included identification by learning styles of some of the students who do not complete the course. Data collection occurred as early as possible after the quarter started.

This study involved the identification of learning styles of students in the NMBC, a course taught by the audiotutorial format to approximately 3500 students per year.

Curry, in Claxton & Murrell (1987), describes personality factors as the core upon which all other learning style variables are built. (See Table 2 in Chapter I for a description of which factors, as described by Curry, are measured by each of the instruments: the Learning Style Profile (LSP) and the Myers-Briggs Type Indicator (MBTI). See Figure 2 in Chapter II for a description of all the LSP subscales. Chapter II also includes a description of the Myers-Briggs Type Indicator.)

According to Curry (1983), information processing and instructional preferences build upon the personality core.

Six subscales classified as cognitive skills are assessed by the LSP: analytic, spatial, discrimination, sequential processing, categorization, and memory. Three subscales classified as perceptual modalities are assessed by the LSP: visual, auditory, and emotive. The remaining 13 subscales are considered physiological/environmental. (See student printout of the LSP in Figure 3 for example of how all variables are reported to an individual). The MBTI assesses eight personality dimensions described by the Claxton & Murrell (1987) and the Curry (1983) learning style paradigm, the paradigm which constitutes the learning style framework used in this study.

DESCRIPTION OF BIOLOGY COURSE FOR NON-MAJORS

The course in biology for non-majors was designed in 1969 from state-of-the-art data available on individualized instruction. Biology 110 was implemented in this mode in 1969 (Meleca, 1973). The course has had modifications over the years; the current delivery format is similar in some ways to the course as it was designed in 1969. In other ways it is quite different. For example, a computer-managed testing component was added in the 1970s. Currently, all student assessment is done by computer. Another change was the removal in 1986 of slides to accompany the audiotape instruction and inclusion of a visual component provided by the textbook.

The objectives of the program, as designed in 1969, are taken from Meleca's article:

> 1. To endow undergraduate students with scientific literacy by means of individualized instruction.
>
> 2. To prepare biology and biology-related majors for upper-division work in subdisciplines of biology.
>
> 3. To give the learner an education in biology that stresses inquiry and the process of science and is based on principles that will stand the test of time (1973, p. 193).

No data were located that show a revision of the objectives of the program in the Bio-Learning Center since the inception of the course in 1969. Biology majors do not currently take the course; special courses are now available for them. However, it is not clear that program objective 2, listed above, is not still a focus of the course.

DESCRIPTION OF BIOLOGY 110 (NMBC)

The description of Biology 110, which follows, is taken from the 1988 Annual Report of General Biology. Biology 110, *General Biology*, is a 5-credit hour course presenting an in-depth introduction to the important basic concepts and principles which tend to unify the study of living organisms at various levels of organization. The course is offered all four quarters of the academic year. Biology 110 is approved for basic education requirements (BER) for students in the college of Arts and Sciences. The course is also available for credit by exemption. Biology 110 may be taken as an elective by a student wishing to fulfill a 5-credit natural science requirement. There are no prerequisites for Biology 110.

Biology 110 is taught by the audiotutorial method, and involves 10 tape-recorded units, of which each is integrated with a corresponding group of laboratory experiments. This instructional component is delivered in the Bio-Learning Center (BLC), where students may work at their individual paces, given the requirement that the student must complete at least one unit of study per week. In addition, the student is required to attend two, one-hour conventional recitation section meetings per week, where specific problems can be discussed.

All testing in Biology 110 is accomplished in the General Biology Testing Center through the Bio-Computer Managed Instruction (Bio-CMI) computer program operating under the Phoenix System on the computer of University Systems Computer Center. The required textbooks for Biology 110 are The World of Biology by Davis and Solomon (1986) and General Biology Laboratory Manual by Eberhard (1985). The syllabus, calendar and instructional objectives for each of the ten units are presented in Appendices A-E.

IDENTIFICATION OF STUDENT LEARNING STYLE

SUBJECTS

The subjects were enrolled in the NMBC during Winter Quarter, 1988. The population of students was 1053 as listed on the third week class rosters. The population of students who took only the LSP (N=922) and the population of students who took both instruments (N=673) were both analyzed separately. (In the case of both instruments, some students who dropped the course and who never actually took a computer-managed test (N=27) were evaluated for their learning style.) Students were administered the instruments during the first two weeks of class, so all students who took both instruments were still enrolled through the second week.

TEST ADMINISTRATION PLAN

Two instruments for measuring learning style were the Learning Style Profile (LSP) produced by the National Association of Secondary School Principals (NASSP) (Keefe et al, 1986) and the Myers-Briggs Type Indicator (MBTI), produced by the Consulting Psychologists Press (1977). Both instruments were administered during Winter Quarter, 1988. During the first week of the quarter, the LSP was administered during the recitation period. Students were given the opportunity to refuse to take the LSP; however, bonus points were given as motivation to participate in the research. (An explanation of these special bonus points can be found in Appendix B). The students present at recitation sections who volunteered (N=922) to do so were given the Myers-Briggs Type Indicator to take home and complete by the following recitation meeting time, the next week. Seven hundred and sixty nine students returned the MBTI for an 83% response rate.

Myers and McCaulley (1985) state that "The MBTI has no time limit..." (p.8). Several authors have used the survey, mail-out design for administration of the MBTI (Campbell, 1986; Shylo, 1985; and Weade, 1984). Steele (1986) administered the MBTI in class over a four day period for a total of one and one half hours.

Bonus points were given to each student for completing either the LSP or the MBTI or both. Students received results from the learning style profile in a computer printout format (Figure 3, p. 46) and written explanation (Appendix G). The meaning of the profile and of learning style was explained in a seminar which was offered near the end of the quarter.

INSTRUMENTATION

Learning Style Profile

The Learning Style Profile (LSP) (Keefe, et al., 1986) administered to the biology students measures 23 subscales of research-based style elements which are classified into cognitive, affective, and physiological/environmental domains. Learning style is a composite of these elements that serves as a relatively stable indicator of how a learner perceives, interacts with, and responds to the learning environment.

The LSP contains 126 items divided among 23 subscales. The LSP internal consistency reliability estimates for each sub-scale measures from 0.47 to 0.76, with an average of 0.61. (Over 5000 students field tested the LSP in grades 6-12 to determine these reliabilities (Keefe, et al, 1986)). Reliability estimates (Cronbach's Alpha) reported by the

NASSP and for the non-majors in Biology 110 are presented in Table 10. The range of reliabilities for the non-major is 0.35-0.89 with an average of 0.68.

TABLE 10

LEARNING STYLE PROFILE
SUBSCALE RELIABILITIES

Cronbach's Alpha

Subscale	Number of Items	Grades 6-12		Biology Non-major Undergraduate	
		n	Alpha	n	Alpha
Analytic Skill	5	4,852	.56	922	.64
Spatial Skill	5	4,967	.60	922	.39
Discrimination Skill	5	5,131	.51	922	.59
Categorizing Skill	8	3,702	.74	922	.74
Sequential Processing Skill	6	4,997	.72	922	.52
Memory Skill	12	4,467	.62	922	.62
Perceptual Response:					
Visual	20	4,766	.51	922	
Auditory	20	4,766	.49	922	
Emotive	20	4,766	.48	922	
Persistence Orientation	4	4,844	.67	922	.75
Verbal Risk Orientation	4	4,745	.55	922	.66
Manipulative Preference	4	4,766	.69	922	.77
Study Time Preference:					
Early Morning	2	4,783	.47	922	.59
Late Morning	2	4,873	.67	922	.89
Afternoon	3	4,765	.60	922	.67
Evening	3	4,903	.58	922	.74
Verbal-Spatial Preference	6	4,220	.76	922	.35
Grouping Preference	5	4,760	.64	922	----
Posture Preference	4	4,750	.52	922	.67
Mobility Preference	4	4,726	.64	922	.75
Sound Preference	4	4,819	.69	922	.81
Lighting Preference	5	4,810	.73	922	.84
Temperature Preference	4	4,802	.72	922	.85

Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) was developed by Isabel Briggs Myers and Katherine C. Briggs (Myers, 1980). The indicator is based on the psychological theory of Carl Jung who identified behaviors in individuals that are due to certain basic differences in the way people prefer to use perception and judgment, behaviors that were previously thought to be based on random variation (Jung, 1921).

The MBTI is one of the most valuable instruments for an initial look into individual differences between persons (Myers, 1980). Claxton & Murrell (1987), using the Curry model, have described personality in relation to learning style as the core ingredient in assessing a person's propensity toward a new learning situation. They list the MBTI as a measure of determining personality components of an individual as those components relate to learning.

McCaulley (1977) has stated that the MBTI can be used to distinguish a "science-minded" individual from one who is not. Gable's (1985) table (2.5) presented in Chapter II shows that, based on a synthesis of five studies, research scientists are all intuitive (N). Claxton & Murrell (1987) report that much data support the hypothesis that intuitive types survive and thrive much better in an academic environment, particularly at the college level. Identification of those individuals who are taking science classes but who are not "science-minded" can be a helpful diagnostic tool for the instructor who is interested in designing instruction for individuals who may think differently from the instructor. According to McCaulley (1977), Myers (1980), and Claxton & Murrell (1987), non-major students in biology may be more sensing than intuitive, and may be more likely to drop out of college, than would intuitive types. Identification of learning style may have implications for teaching as well as for learning.

Reliability of the MBTI of the nine samples related to post-secondary education, according to Gable (1985), were in the .68-.90 range, except for one estimate of .63, using the split-half technique on each of the four scales. The Alpha reliability ranged from 0.71-0.84, according to Gable.

VARIABLE NAMES

Table 11 presents variables collected in this study. An explanation of the origin of each variable follows the table, in the descriptions of formation of the data bases.

TABLE 11

VARIABLE NAMES:
LIST, DESCRIPTION, AND LOCATION

Name	Description	Database 1 LSP	Database 2 MBTI/CMI	Database 3 Admissions
C1	Analytic skill score* on LSP	X		
C2	Spatial skill score on LSP	X		
C3	Discrimination skill score on LSP	X		
C4	Categorization skill score on LSP	X		
C5	Sequencial Processing skill score on LSP	X		
C6	Memory skill score on LSP	X		
C7	Visual perceptual response score on LSP	X		
C8	Auditory perceptual response score on LSP	X		
C9	Emotive perceptual response score on LSP	X		
C10	Persistence orientation score on LSP	X		
C11	Verbal Risk orientation score on LSP	X		
C12	Manipulative preference score on LSP	X		
C13	Early morning study time preference score on LSP	X		
C14	Late morning study time preference score on LSP	X		
C15	Afternoon study time preference score on LSP	X		
C16	Evening study time preference score on LSP	X		
C17	Verbal-Spatial preference score on LSP	X		
C18	Grouping preference score on LSP	X		
C19	Posture preference score on LSP	X		
C20	Mobility preference score on LSP	X		
C21	Sound Preference score on LSP	X		
C22	Lighting Preference score on LSP	X		
V23	Temperature Preference score on LSP	X		
M1	Standard score of first letter of MBTI type		X	
M2	Standard score of second letter of MBTI type		X	
M3	Standard score of third letter of MBTI type		X	
M4	Standard score of fourth letter of MBTI type		X	
M5	Extroversion raw score		X	
M6	Sensing raw score		X	

Table 11, continued

Name	Description	Database		
		1 LSP	2 MBTI/CMI	3 Admissions
M7	Thinking raw score		X	
M8	Judging raw score		X	
M9	Introversion raw score		X	
M10	Intuition raw score		X	
M11	Feeling raw score		X	
M12	Perceiving raw score		X	
PS1	Achievement score on Biology 110 computer-managed tests, first try total for entire course, percentage		X	
PS2	Achievement score on Biology 110 computer-managed tests, best try total for entire course, percentage		X	
Rank	Subject's rank in college			X
R1->R23	Raw scores on LSP variables, same name as C1-C23, above	X		
Sex	Subject's sex	X		
SSN	Social Security Number	X	X	X
Type	MBTI psychological 4 letter type		X	
T1	First letter of MBTI type		X	
T2	Second letter of MBTI type		X	
T3	Third letter of MBTI type		X	
T4	Fourth letter of MBTI type		X	
V1->V126	Items on the Learning Style Profile	X		

*C1->C23=standard score

FORMATION OF DATA BASE

During Winter Quarter 1988, 1053 students enrolled in 40 recitation sections of the NMBC at The Ohio State University. These students were the primary population studied in this research.

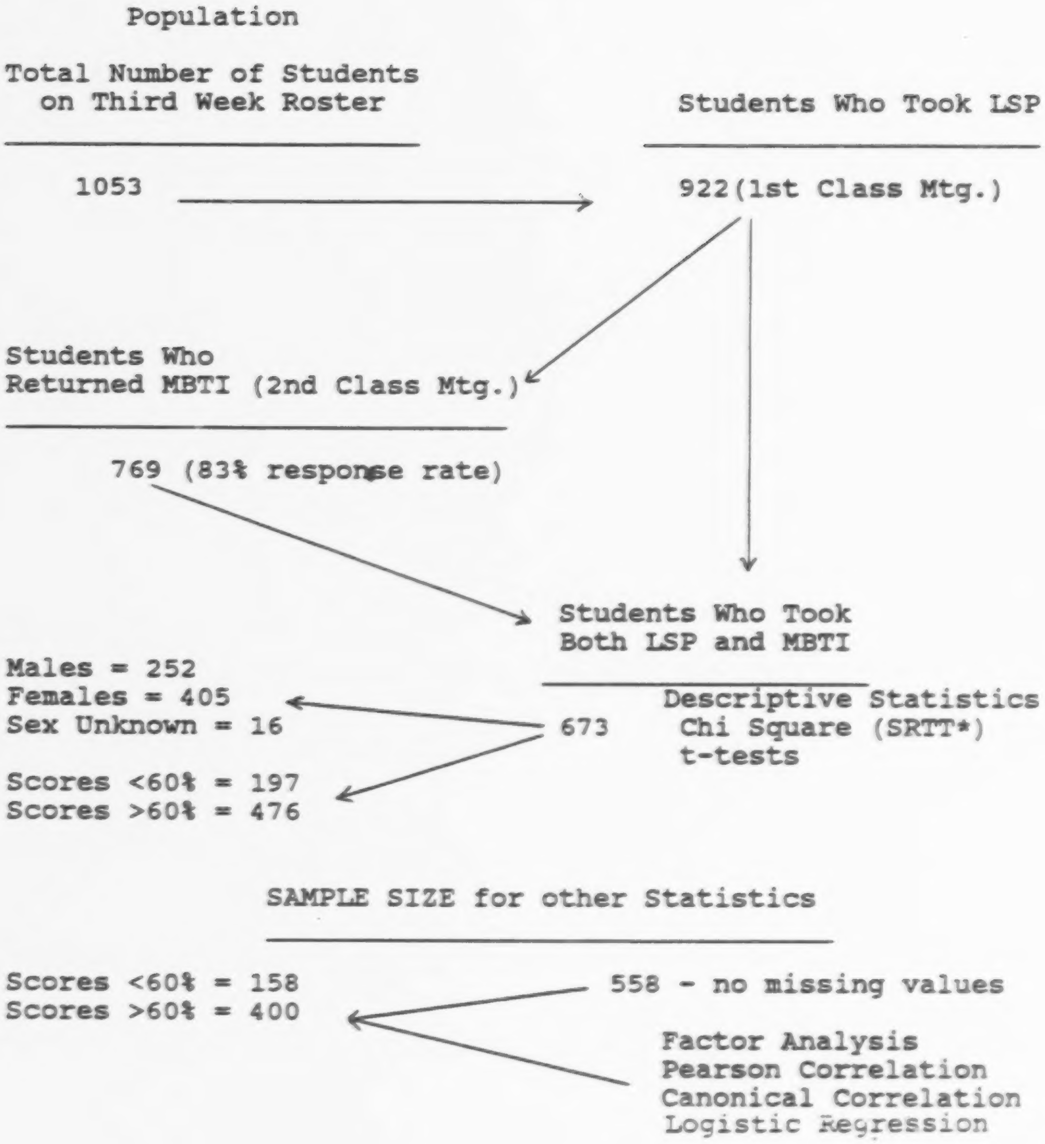
During the first week of Winter Quarter, 1988, the Biology 110 recitation instructors, who had been briefed (in person, to most of them, and by written communication) by this researcher as to the details of administering the Learning Style Profile administered the instrument to the students. Each student who took the LSP recorded his/her name, sex, rank, race, birthdate, social security number, and recitation section. Responses produced by the 126 items on the LSP were recorded on the National Association for Secondary School Principals (NASSP) answer sheet Changes were made from instructions for filling out and the answer sheet given in the Examiner's Manual for the college population. For example, the eight digit identification number on the LSP answer sheet was adapted for nine digit social security numbers (Appendix G, number 4 addresses those changes).

The NASSP answer sheets were optically scanned at the Testing Center of The Ohio State University and processed by a scoring program written by Dr. John Monk, Grant Hospital, Columbus, Ohio. This scoring program created an on-line data file containing the raw LSP data and the scored LSP data, which consisted of scores in all 23 of the LSP subscales.

Students who attended recitation during the first week, who voluntarily took the MBTI home, and then returned it during recitation the second week, composed the population that took both the LSP and the MBTI. The MBTI responses were recorded by students on NCS answer sheets and were scored on an NCR microcomputer with a BASIC program (GWBASIC Manual, Version 1.4). (A display of an answer sheet and the report produced by the program is also in Appendix H.)

Performance data from The Ohio State University's Phoenix computer-managed testing system (managed and operated by the Center for Teaching Excellence at The Ohio State University) were collected daily, by quarter, as the students took tests. A single student record of achievement is displayed in Appendix J.

Student performance data were computed for the quarterly point total for the cumulative first test try and for the final cumulative best test try. The final score is expressed as a percentage. The actual cumulative best try point total was computed as a percentage of the total points possible (406) for the quarter. For example, a best test total of 101 points would yield a 25% score in the NMBC. (Point total information for each letter grade is included on page 11 of the Facilities, Policies and Procedures for the NMBC, Appendix D.) Point total figures for first try were determined by adding all first test results on the student record (Appendix J) and dividing by the possible total, 406. For example, a first test total of 247 would yield a 61%. These two point figures compose the variables, PS1 (performance score first try) and PS2 (performance score best try). Demographic information [as displayed in the variables table (3.2)] for the students corresponding to each social security number was collected. Rank and race information were sought to determine if there was any difference in achievement because of these variables. College and major were obtained. Almost every college in the university was represented and the majors were too numerous to be useful, so these data were not used in the study (A listing of college majors is presented in Appendix K). The most numerous majors listed were unknown, 142; education, 90; pre-nursing, 27; home economics, 27; accounting, 26; agriculture (economics, education, undecided), 26; business, 58; pre-pharmacy, 35; and pre-physical therapy, 37.


Population
Total Number of Students on Third Week Roster
1053
Students Who Took LSP
922(1st Class Mtg.)
Students Who Returned MBTI (2nd Class Mtg.)
769 (83% response rate)
Students Who Took Both LSP and MBTI
673
Descriptive Statistics
Chi Square (SRTT*)
t-tests
Males = 252
Females = 405
Sex Unknown = 16
Scores <60% = 197
Scores >60% = 476
SAMPLE SIZE for other Statistics
558 - no missing values
Scores <60% = 158
Scores >60% = 400
Factor Analysis
Pearson Correlation
Canonical Correlation
Logistic Regression

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*Selection Ratio Type Table

Figure 4. Schema of Population, Sample and Types of Statistical Procedure

Summary of Components of Data Base

The subjects of the admissions data, and the limit of them, are the volunteer students enrolled in the NMBC who chose to take the Learning Style Profile. Approximately 125 students listed on the third week rosters did not take the LSP. These students were not tracked for their ultimate success or failure in the course, their learning style, or any other of the variables selected for analysis.

Attendance records show that as any given quarter progresses, attendance declines in the recitation sections. The learning style instruments were given during the first class recitation meeting (see course schedule in the syllabus in Appendix A) in the hopes of getting the greatest number of students to participate. Additionally, bonus points were given to the students, for each instrument completed, to elicit their participation. Still, participation in the learning style research was voluntary; therefore, it is not surprising that one tenth of the enrolled group chose not to participate.

This data base described then formed the basis for the research. The number of students who took the LSP differs from the number of students who took the MBTI. The students took the LSP in class. In the interest of instructional time, they were given the MBTI to take home and voluntarily submit it for credit.

STATISTICAL PROCEDURES

Descriptive statistics were performed on the raw and scaled scores of both instruments including mean scores and standard deviations of raw and scaled scores of the LSP. Frequencies of MBTI types have been determined as well as performance by MBTI types. Two special populations of students have been given close examination, students who took both instruments, the LSP and the MBTI, and who scored less than sixty percent (N=197) on the computer-managed test system or who dropped the course after staying in class through the second week but before ever attempting a computer-managed test.

The computer-managed test system is the way students receive 92% of their final score during a regular quarter in the NMBC, a quarter in which bonus points for taking the LSP and MBTI are not offered. These special populations illuminate just which combination of learning style variables, from personality components to instructional preferences, social interactions and information processing skills, are most at risk in this biology course for non-majors. Statistical procedures used to study these and other populations help answer the question regarding whether or not, as Curry (1983) suggests, the personality component of learning style can predict the other components in the learning style framework.

SELECTION RATIO TYPE TABLE (SRTT) ANALYSIS

Macdaid (1987) writes that one of the most common hypotheses in MBTI type research addresses whether certain types are found more frequently in a given sample than would be expected in a base population. The appropriate analysis is a two-by-two contingency table analysis, in which the columns are a given MBTI type vs all other MBTI types; the rows are, for the analyses described herein, non-majors in biology vs various other comparison groups. Macdaid describes the null hypothesis: if type does not affect selection into the sample, then the proportion of any type observed in the sample will not differ from the proportion of that same type in a reference population (p. 254). This analysis tests to see if the observed frequencies are the same or different than expected frequencies. A chi-square statistic is calculated for the hypothesis test; if the probability of the calculated chi- square value is less than the alpha level chosen ($p < .05$), then rejection of the null hypothesis occurs. It is then possible, according to Macdaid, to conclude that type factors are significant in that particular sample. Samples in this study for the SRTT analysis are the total non-major group, males in the non-major group, and the group whose final cumulative computer test score was less than 60%. Comparative groups are biology majors and male science students reported by McCaulley (1977), biologists (CAPT, 1986), and the group whose final cumulative computer test score was equal to or greater than 60%.

The chi-square analyses for the study were completed by Dr. Leverne Barrett, Department of Agriculture Education at The University of Nebraska, an experienced MBTI user (Provost & Anchors, 1987, pp. 278-9), using the Selection Ratio Type Table (SRTT) computer program .

ADDITIONAL STATISTICAL PROCEDURES

Other statistical procedures used in the study included ANOVA descriptive statistics (means and standard deviations), Pearson correlation coefficients, factor analysis, canonical correlation and logistic regression. All procedures were performed on The Ohio State University Computing System, IBM 3081, using the SAS programming language.

SUMMARY

This chapter describes the overall design of the study. The chapter includes: a description of Biology 110, the NMBC, an audiotutorial computer-managed course for non- majors in biology at The Ohio State University.; descriptions of both learning style instruments used in the study, Learning Style

Profile and Myers-Briggs Type Indicator; and descriptions of test administration plans.

Chapter III describes how the data base was formed and merged to complete the analysis of the data. The final portion of the chapter describes the statistical procedures used to obtain the results, which are presented in the next chapter.

CHAPTER IV

RESULTS

ORGANIZATION OF THE CHAPTER

This chapter is organized in six sections:

1. Descriptive information on the population and the sample subjects in the study, presented in tabular form, and followed by explication when needed.
2. Descriptive statistics of the two instruments, Learning Style Profile (LSP) and Myers-Briggs Type Indicator (MBTI), for the subjects in the population studied. Hypotheses 1, 2, 3 and 4 are addressed in section two.
3. Analysis of the cognitive process components of a sample of the achievement test questions, with concommitant student cognitive process scores as measured by the Learning Style Profile. Hypothesis 5 is addressed in section three.
4. Results of canonical correlation, a test of Hypothesis 6. Correlation coefficients, factor analysis, and logistic regression results are presented.
5. List of findings of educational importance.

DESCRIPTIVE INFORMATION OF STUDENT POPULATION

Student background information provided by the admissions office is presented in Tables 12 through 13. Rank frequencies of those students enrolled in the course and those who took both learning style instruments are presented in Tables 12 and 13. Over half of the population (54.2%) held the rank of freshman; another 27.6% were sophomores, with fewer at other undergraduate levels. About 3% of the population were nontraditional, including continuing education, non-degree, and graduate students.

Race frequencies of students enrolled in the course and those who took both learning style instruments are presented in Tables 4.3 and 4.4. Almost 83 percent of the population was white, as were over 89% of the students who took both learning style instruments. Blacks constituted 5.5% of the population and 5.2% of the tested sample.

TABLE 12

RANK DISTRIBUTION OF POPULATION OF NON-MAJOR UNDERGRADUATES IN BIOLOGY

Rank	Population	Percent of Total
Freshman	486	54.2
Sophomore	247	27.6
Junior	86	9.6
Senior	46	5.1
Nontraditional[a]	31	3.5
Total	896	100.0
Unidentified[b]	157	
Total on Rosters 3rd Week	1053	

---

[a] Includes continuing education, non-degree, and graduate students

[b] Unidentified students were of two categories--those whose SSNs were illegible on LSP (n=~60) or those who did not take LSP (n=~97)

TABLE 13

RANK DISTRIBUTION OF STUDENTS WHO TOOK BOTH LEARNING STYLE PROFILE AND MYERS-BRIGGS TYPE INDICATOR

Rank	Population	Percent of Total
Freshman	360	54.9
Sophomore	175	26.7
Junior	64	9.8
Senior	33	5.0
Nontraditional[a]	24	5.6
Total	656	100.0
Missing Cases	17	
	673	

---

[a] Includes continuing education, non-degree, and graduate students

TABLE 14

RACE DISTRIBUTION OF POPULATION OF NON-MAJOR UNDERGRADUATES IN BIOLOGY

Race	Frequency	Percent of total
Am Ind/AK NA	2	0.2
Asian/Pac Is	23	2.4
Black	53	5.5
Hispanic	2	0.2
None Given[a]	84	8.8
White	792	82.8
Total	956	100.0
Unidentified[b]	97	
Total on Rosters 3rd Week	1053	

[a] Admissions Office has no race data on student

[b] Unidentified students were of two categories: those whose SSNs were illegible on LSP (n=~60) or those who did not take the LSP (n=~37)

TABLE 15

RACE DISTRIBUTION OF STUDENTS WHO TOOK BOTH LEARNING STYLE PROFILE AND MYERS-BRIGGS TYPE INDICATOR

Race	Frequency	Percent of total
Am Ind/AK NA	2	0.3
Asian/Pac Is	16	2.4
Black	34	5.2
Hispanic	2	0.3
None Given[a]	17	2.6
White	585	89.2
	656	100.0
missing cases	17	
Total	673	

[a] Admissions Office has no race data on student

DESCRIPTIVE STATISTICS OF TWO INSTRUMENTS

Table 4.5 contains the raw score means, standard deviations and sample sizes for the non-majors in biology and the twelfth grade data (only), provided from the Technical Manual for the Learning Style Profile (Keefe & Monk, 1988). Differences were found between twelfth grade and college populations on subscale skills of analytic, spatial, sequential processing, and memory; subscale perceptual modalities of visual and auditory; subscale orientations of persistence and verbal risk; subscale study time preferences of late morning and evening; and subscale environmental preferences of posture, mobility, sound, and lighting. All differences were significant at the level of $p < 0.0001$.

Table 4.6 displays standard mean scores and standard deviations for all of the students who took the Learning Style Profile (n=922). Standard scores for the non-majors were obtained using the NASSP Computer Scoring Program. Standard scores for the twelfth grade population were not available for a comparison.

Students are above average strength in spatial, categorization, and sequential processing skills, while analytic skill was at the median. Discrimination and memory skills for the non-major population were below average.

For perceptual modality preferences, students prefer visual instruction over auditory. Emotive preference is at the median.

Students show slightly below average preferences and orientations for persistence, verbal risk, and manipulative opportunities. Preferred study time is in the evening followed by slightly above average preferences for morning and afternoon study times. The late morning preference is at the median.

Verbal-spatial preference tends slightly toward spatial, in agreement with above average skill in spatial ability, mentioned previously. The population of non-majors in biology prefers formal and small group instruction to informal large group instruction. They have a preference for quietness in a bright and warm environment.

TABLE 16

COMPARISON OF TWO POPULATIONS ON THE LEARNING STYLE PROFILE (LSP)[a]

	The Ohio State University Non-Majors in Biology			Grade 12[b]			Difference[c]
LSP Subscale	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**	**N**	**Between Means**
	Raw Score			Raw Score			
Analytic Skill	2.56	1.22	922	2.97	1.52	893	****
SpatialSkill	3.52	1.20	922	3.04	1.45	899	****
Discrimination Skill	2.72	1.44	922	2.96	1.50	902	NS
Categorization Skill	10.02	3.95	922	data not available			---
Sequential Processing Skill	5.57	0.84	922	5.27	1.20	902	****
Memory Skill	5.11	2.87	922	6.13	2.67	874	****
Visual	9.84	3.07	922	8.79	2.95	892	****
Auditory	3.37	2.26	922	4.28	2.41	892	****
Emotive	6.68	2.63	922	6.86	2.62	892	NS
Persistence Orientation	13.33	2.83	922	12.79	2.68	889	****
Verbal Risk Orientation	11.91	2.93	922	12.98	2.95	884	****
Manipulative Prefence	12.35	3.45	922	12.77	3.23	889	NS
Early Morning	5.81	1.84	922	5.90	1.66	867	NS
Late Morning	5.74	1.91	922	6.23	1.77	881	****
Afternoon	10.02	2.36	922	9.91	1.90	864	NS
Evening	9.85	2.49	922	8.88	2.61	882	****
Verbal-Spatial Preference	3.38	1.33	922	3.46	1.75	876	NS
Grouping Preference	14.81	2.67	922	15.03	2.29	887	NS
Posture Preference	13.28	3.30	922	12.04	2.93	880	****
Mobility Preference	12.78	3.30	922	13.59	2.98	870	****
Sound Preference	9.71	3.50	922	11.93	3.52	892	****
Lighting Preference	15.68	4.26	922	14.72	4.13	890	****
Temperature Preference	12.72	3.60	922	12.40	3.39	889	NS

[a] Produced by National Association of Secondary School Principals, Reston, Virginia

[b] Technical Manual for Learning Style Profile

[c] The T statistic was calculated by taking into account the difference of variability of the two groups

[d] underline indicates which group scored higher

****p<.0001

NS = Difference not significant

TABLE 17

LEARNING STYLE PROFILE SUMMARY DATA

This profile is for: Non-science major undergraduates N=922

Birthdate: **Sex**: **Grade**: **Race**:
Date: Winter 1988 **School**: The Ohio State University **Class**: Biology 110

Skills--General approach to processing information

	Score	S.D.	Weak	Average		Strong
Analytic	50.32	8.12		XX	XX	
Spatial	53.98	12.24			XXXX	
Discrimination	46.56	10.77		XXXX		
Categorization	56.96	7.90			XXXX	
Sequential	54.30	5.47			XXXX	
Memory	46.64	11.18		XXXX		

Perceptual responses--initial response to verbal information

	Score	S.D	Weak	Average		Strong
Visual	53.87	10.66			XXXX	
Auditory	44.73	9.39		XXXX		
Emotive	49.84	10.31		XX	XX	

Orientations and preferences--
Preferred response to study or instructional environment

	Score	S.D	Weak	Average		Strong
Persistence	48.89	9.86		XXXX		
Verbal Risk	48.75	9.32		XXXX		
Manipulative	48.44	10.34		XXXX		
Study Time:						
Early Morning	50.59	10.74			XXXX	
Late Morning	49.57	9.47		XX	XX	
Afternoon	50.69	9.31			XXXX	
Evening	52.75	9.05			XXX	

				High	Neutral		High	
Verbal-Spatial	48.09	6.93	Spatial		XX			Verbal
Grouping	41.50	7.07	Small		XX			Large
Posture	54.81	10.35	Informal			XX		Formal
Mobility	48.07	9.77	Stillness		XX			Movement
Sound	44.13	9.36	Quiet		XX			Sound
Lighting	52.14	10.04	Dim			XX		Bright
Temperature	53.29	10.37	Cool			XX		Warm

Consistency score: 5 Normative sample: 1986 -- National
NASSP--National Association of Secondary School Principals, Reston, VA

Scale Indicators

Weak, Low or High					Average or Neutral					Strong or High	
< 30	30-35	36-40	41-43	44-47	48-	52	53-56	67-59	60-64	65-70	> 70

Standard Score Range

COMPONENTS OF PERSONALITY TYPE AMONG NON-MAJORS IN BIOLOGY

Table 18 presents frequencies of all students by sex and MBTI type among the non-majors in biology. These non-major groups are compared, in hypotheses 1, 2 and 3, to reference populations of biology majors, science majors, and biologists. Within some cells of Table 18, the sum of female and male Ns is less than the reported N because 2% of the respondents did not report their sex. Therefore, sex is known for only 657 of the 673 non majors.

Table 19 presents summary data for single letter preferences (figures reported are percents) for the non-major population in this study. In the non-major population, 61.4% are E and 38.6% are I. 60.6 % are S and 39.4% are N, 40.9% are T and 59.1% are F, and 50.1% are J and 49.9% are P.

Thus the largest percentages of each dimension produce a profile of the non-major in biology: Extroverted, Sensing and Feeling (ESF-). The J-P dimension, for the total population, is almost equally divided in this analysis.

COMPONENTS OF PERSONALITY TYPE IN THE GENERAL POPULATION

Original estimates of the personality components by Myers can be observed in Table 20. Actual figures, by McCaulley, of personality components in the overall population, are presented in Table 21. Tables 20 and 21 are provided for comparison with the non-major population. No statistical

TABLE 18

MBTI FREQUENCY DISTRIBUTION
NON-MAJOR UNDERGRADUATES IN BIOLOGY

Population Size = 673*

ISTJ F=18 M=31 N=49 %=7.3	ISFJ F=51 M=11 N=64 %=9.5	INFJ F=8 M=8 N=16 %=2.4	INTJ F=5 M=6 N=11 %=1.6
ISTP F=5 M=18 N=26 %=3.9	ISFP F=22 M=19 N=42 %=6.2	INFP F=14 M=14 N=28 %=4.2	INTP F=10 M=14 N=24 %=3.6
ESTP F=13 M=28 N=42 %=6.2	ESFP F=39 M=15 N=54 %=8.0	ENFP F=58 M=21 N=83 %=12.3	ENTP F=22 M=14 N=37 %=5.5
ESTJ F=25 M=31 N=58 %=8.6	ESFJ F=67 M=4 N=73 %=10.8	ENFJ F=35 M=3 N=38 %=5.6	ENTJ F=13 M=15 N=28 %=4.2

*Female =405, %= 60
Male =252, %= 37
Sex unknown - %= 2

Total 100

TABLE 19

COMPARISON OF SUMMARY DATA FOR "PERSONALITY TYPE COMPONENTS" NON-MAJOR UNDERGRADUATES IN BIOLOGY

Population Sample = 673

Composite by %	E	I	S	N	T	F	J	P
	61.4	38.6	60.6	39.4	40.9	59.1	50.1	49.9
F	67.2	32.8	59.3	40.7	27.4	72.6	54.8	45.2
M	52.0	48.0	62.3	37.7	62.3	37.7	43.3	56.7

TABLE 20

GENERAL POPULATION FREQUENCY ESTIMATES BY COMPONENT OF PERSONALITY TYPE

(Myers in McCaulley et al., 1985)

Composite by %	E	I	S	N	T	F	J	P
	75.0	25.0	75.0	25.0	60.0	65.0	55-60.0	40-45.0
					Males	Females	Myers reports this range	

TABLE 21

GENERAL POPULATION FREQUENCIES BY COMPONENT OF PERSONALITY TYPE

(McCaulley et al., 1985) N = 50,000

Composite by %	E	I	S	N	T	F	J	P
Females	59.7	40.3	67.8	32.2	34.6	65.5	59.8	40.2
Males	53.9	46.1	65.6	34.4	65.0	35.0	59.3	42.7

comparisons have been attempted because Myers' figures are only estimates and McCaulley did not report separate Ns for females and males. These general population data are presented for interest only and should not be confused with the McCaulley studies of biology majors and male science majores presented in testing of hypothesis one and two.

A few generalizations can be made from visual observation of the data, however. In comparison to the general population, the non-majors group has fewer Extroverts (61.4%) than Myers reports (75%). McCaulley et al. (1985) report about the same frequencies of the E-I scale as those found in the non-major population. The non-majors include fewer sensing (S) individuals (60.6%) than reported by Myers, estimates (75%) or by McCaulley's population (67.8% or 65.6%). The thinking-feeling dimension (T-F) differs little among the three groups.

The J-P dimension is divided more equally in the non-major population (J=50.1%, P=49.9%) than in either the McCaulley or the Myers populations, which favor J (Myers, 55-60% J range; McCaulley around 60% for both males and females).

A major difference occurs in the male population on the J-P scale between non-majors and McCaulley's males. Non-major males are 43.3% J compared to 56.7% P. For McCaulley the reverse is true: among males in the general population, 42.7% are P while 59.3% are J.

COMPARISON OF THREE POPULATIONS ON THE MBTI

Table 4.11 displays percentages of three student populations, from which hypotheses 1-3 were tested. As soon as it became obvious that there was such disparity between the types by major, data were re-examined. This process produced Table 4.12 which was extracted from Table 4.11. (To see how the data on Table 4.12 were obtained, add the percentages of persons in the first column of the row beginning with ISTJ, by their group (1, 2, or 3). For example, group 1, Biology majors percentage in the ST column is 11.0 + 4.1 + 4.1 + 5.1 for a total in Table 4.12 of 24.3 ST for group 1, biology majors.)

Table 4.12 contains information about the percentages of two-letter combinations of perception [Sensing (S) and Intuition (N)] and judgment, [Thinking (T) and Feeling (F)], in the three student populations. These comparisons and differences guided the hypotheses testing which follows.

TABLE 22

COMPARISON OF THREE POPULATIONS ON THE MBTI

1 Biology majors N=98 (McCaulley, 1977)
2 Male Science majors N=705 (McCaulley, 1977)
3 Non-majors in Biology N=673 (The Ohio State University, 1988)

	ISTJ	ISFJ	INFJ	INTJ
1	N=11 %=11.0	N=8 %=8.2	N=2 %=2.0	N=6 %=6.1
2	N=39 %=5.5	N=12 %=1.7	N=44 %=6.2	N=128 %=18.2
3	N=49 %=7.3	N=64 %=9.5	N=16 %=2.4	N=11 %=1.6
	ISTP	**ISFP**	**INFP**	**INTP**
1	N=4 %=4.1	N= 5 %=5.1	N=11 %=11.2	N=4 %=4.1
2	N=18 %=2.6	N=15 %=2.1	N=58 %=8.2	N=123 %=17.4
3	N=26 %=3.9	N=42 %=6.2	N=28 %=4.2	N=24 =3.6
	ESTP	**ESFP**	**ENFP**	**ENTP**
1	N=4 %=4.1	N=4 %=4.1	N=11 %=11.2	N=5 %=5.1
2	N=12 %=1.7	N=1 %=0.1	N=55 %=7.8	N=79 %=11.2
3	N=42 %=6.2	N=54 %=8.0	N=83 %=12.3	N=37 %=5.5
	ESTJ	**ESFJ**	**ENFJ**	**ENTJ**
1	N=5 %=5.1	N=6 %=6.1	N=4 %=4.1	N=8 %=8.2
2	N=13 %=1.8	N=8 %=1.1	N=27 %=3.8	N=73 %=10.4
3	N=58 %=8.6	N=73 %=10.8	N=38 %=5.6	N=28 %=4.2

TABLE 23

PERCENTS AND COMPARISON OF TWO LETTER COMBINATIONS [a] OF PERSONALITY COMPONENTS OF THREE POPULATIONS ON THE MBTI

1 Biology Major N=98 (McCaulley, 1977)
2 Male Science Major N=705 (McCaulley, 1977)
3 Non-majors in Biology N=673 (The Ohio State University, 1988)

Students by Major	Percent			
	ST	SF	NT	NF
1) Biology Major	24.3	23.5	23.5	28.5
2) Male Science Major	11.6	5.0	57.2	26.0
3) Non-Majors in Biology	26.0	34.5	14.9	24.5
Comparisons of Z				
1) vs 2)	3.48***	6.61***	-6.26***	0.53 NS
1) vs 3)	-0.36 NS	-2.16*	2.17*	0.85 NS
2) vs 3)	-6.86***	13.84***	16.30***	0.64 NS

[a] Refer to Table 2.3 to facilitate interpretation.

NSNo significant difference
*Significant difference, p<.05
***Significant difference, p<.001

The information in Lawrence's Table 5 (p. 43) describes what kind of learning preferences can be expected by persons with these two letter combinations of perception and judgement functions.

The most obvious difference is between the percentages of NTs and SFs among the groups. Non-majors are only 14.9% NT, while biology majors are 23.5% ($p < .05$). Science majors (all males) are 57.2% NT compared to non-majors ($p < .001$). Because T is more frequent in males, a somewhat larger percentage is expected, but it is not likely that all of the difference can be explained by gender. It is more likely that the choice of science major is a factor in the concentration of intuitive (N) and thinking (T). Gable (1985) reports (Table 7, p.40) that 100% of research scientists are the NT combination.

The largely SF non-major (around 60% of both S and F, from Table 4.8, p. 98) is opposite in psychological type from the traditional male science major, who is largely NT. Non-majors in in biology are 34.5% SF, while the biology majors are 23.5% SF ($p < .05$). Greater differences are observable between SF male science majors (5.0%) and the 34.5% SF non-majors ($p < .001$), as well as between SF biology majors (23.5%) and SF male science majors (5.0%) ($p < .001$).

COURSE DEMANDS

An explanation, based on Lawrence's (1984) data, presented in Table 5 (p. 38) is that the ST and the NT types in the NMBC probably find the course to their liking. The course provides most of the components listed by Lawrence as desired preferences by both of these two-letter types: for the ST - labs, television (videotapes are shown weekly in the recitation sections, see course calendar in Appendix A), having a plan and sticking to it; for the NT - organized teacher lectures, self instruction, reading and systematically organized courses. The description preferred by the NT fits the description of the NMBC, in this researcher's view.

The SF and NF type preferences for learning contain some elements that are in the NMBC: SF -television, films and videotapes, all mimic the videotapes shown in recitation, and having a study schedule. However, missing elements are student involvement in demonstrations, presentations, and any instruction with personal involvement.

NF types are at a disadvantage in that none of the learning preferences that Lawrence found are available in the NMBC. According to Lawrence (1984), the NF type really dislikes impersonal, didactic instruction without any opportunity for personal involvement or feedback from others. NF types value other students' participation and opportunities to be creative. There is no provision in the NMBC for any of these components of learning that are valued and preferred by the NF learner.

HYPOTHESIS 1. There is no difference in the distribution of psychological types, as measured by the Myers-Briggs Type Indicator, among the non-majors in the NMBC and among majors in biology (McCaulley, 1977).

A comparison of the non-majors in the present study with majors in biology reported by McCaulley (1977) is presented in Table 4.13. The Selection Ratio Type Table (SRTT), described in Chapter III, was used to perform chi-square analysis for the non-majors in this study with the majors in biology.

The "I" selection index shown displays the selection index of the various types. Next to the selection ratio is a symbol (*) which denotes the level of significance reached. The lack of a symbol (*, ** or ***) means that the selection ratio index for that type combination failed to reach the lowest level of significance and therefore does not differ from the base population.

Reference samples used in this study (H1, H2, and H3) are biology majors, science majors, and biologists (CAPT Atlas of Type Tables, 1986). For the students whose final cumulative computer test score was <60%, the reference population was the students whose final cumulative computer test score was 60% or greater (H4).

TABLE 24

COMPARISON[a] OF NON-MAJORS (1) IN BIOLOGY (N=673) WITH MAJORS[b] (2) IN BIOLOGY (N=98)

	ISTJ	ISFJ	INFJ	INTJ
1	N=49 %=7.3	N=64 %=9.5	N=16 %=2.4	N=11 %=1.6
2	N-11 %=11.0	N=8 %=8.2	N=2 %=2.0	N=6 %=6.1
	I=0.65	I=1.16	I=1.16	I=0.27**
	ISTP	ISFP	INFP	INTP
1	N=26 %=3.9	N=42 %=6.2	N=28 %=4.2	N=24 %=3.6
2	N=4 %=4.1	N=5 %=5.1	N=11 %=11.2	N=4 %=4.1
	I=0.95	I=1.22	I=0.37**	I=0.87
	ESTP	ESFP	ENFP	ENTP
1	N=42 %=6.2	N=54 %=8.0	N=83 %=12.3	N=37 %=5.5
2	N=4 %=4.1	N=4 %=4.1	N=11 %=11.2	N=5 %=5.1
	I=1.53	I=1.97	I=1.10	I=1.08
	ESTJ	ESFJ	ENFJ	ENTJ
1	N=58 %=8.6	N=73 %=10.8	N=38 %=5.6	N=28 %=4.2
2	N=5 %=5.1	N=6 %=6.1	N=4 %=4.1	N=8 %=8.2
	I=1.69	I=1.77	I=1.38	I=0.51

[a] Legend: % = percentof total choosing this group who fall into this type.
I = self selection index; ratio of % of type in group to % in sample
* = p<.05
** = p<.01
*** = p<.001

[b] McCaulley, (1977)

There are only two of the 16 types that show significant differences: two introverted intuitive types, (INTJ, INFP) are significantly less represented in the non-major group than in the biology major group. Significance of p < .01 is indicated by the index of 0.27 for the INTJ (see legend on Table 24). Likewise the Index of 0.37 for the INFP demonstrates that non-majors in biology compose significantly less of this type than do biology majors reported by McCaulley. The index for the INFP is significant at the 0.01 level.

These data present evidence that the psychological types of the non-major in biology are significantly different than the psychological types of the major in biology. Therefore, hypothesis one is rejected.

HYPOTHESIS 2. There is no difference in the distribution of psychological types, as measured by the Myers-Briggs Type Indicator, among the male non-majors in Biology 110 and male science majors (McCaulley, 1977).

Because all of McCaulley's science major data were from male respondents, the non-majors were separated by sex and only male non-science majors were used for the SRTT chi-square comparison. These data are presented in Table 25. Because of the large number of comparisons performed in this table, higher significance levels ($p < .003$) are necessary to detect experimentally based alphas of .05.

Eleven of the 16 types show significant differences between the two groups. The types that are significantly less represented in the non-major in biology group are INTJ ($p < 0.001$), INTP ($p < 0.001$), ENTP ($p < 0.01$), and ENTJ ($p < 0.05$). Less representation among these four groups is demonstrated by the index (I) value less than one. All four of these groups share both the intuitive (N) and thinking judgement (T) dimensions, described by Gable (1985) as the most commonly found types among research scientists. Groups which are significantly more represented in the non-major population than in the science major population are ISTJ ($p < 0.01$), ISFJ ($p < 0.01$), ISTP ($p < 0.001$), ISFP ($p < 0.001$), ESTP ($p < 0.001$), ESFP ($p < 0.001$), and ESTJ ($p < 0.001$). The indices and levels of significance are high in all of these groups. That is, any index number greater than one indicates that there is a ratio of that number, to one, in the experimental group compared to the reference group. For example, for the ISTJ there are 2.22 times as many represented in the non-major group than in the science major group.

Five of the eight Sensing types are significantly more represented in the non-major population than in the science major population. Two other S types (FSTJ and ISFJ) are at the level of $p < .01$. The ESFJ shows no significant difference. The ESTP and ESTJ show a ratio of almost seven to one non-majors to majors in science. The ESFPs, with a ratio of 41.96, are extremely more represented in the non-major population. This could demonstrate that the ESFP is most different from science majors.

These data support Gable's (1985) data. Hypothesis 2 is rejected.

TABLE 25

COMPARISON[a] OF MALE NON-MAJORS IN BIOLOGY (1)(N=252) WITH MALE SCIENCE MAJORS[b] (2) (N=705) by MBTI TYPE

	ISTJ	ISFJ	INFJ	INTJ
1	N=31 %=12.3	N=11 %=4.4	N=8 %=3.2	N=6 %=2.4
2	N=39 %=5.5	N=12 %=1.7	N=44 %=6.2	N=128%=18.2
	I=2.22**	I=2.56**	I=0.51	I=0.13***
	ISTP	ISFP	INFP	INTP
1	N=18 %=7.1	N=19 %=7.5	N=14 %=5.6	N=14 %=5.6
2	N=18 %=2.6	N=15 %=2.1	N=58 %=8.2	N=123%=17.4
	I=2.80***	I=3.54***	I=0.68	I=0.32***
	ESTP	ESFP	ENFP	ENTP
1	N=28 %=11.1	N=15 %=6.0	N=21 %=8.3	N=14 %=5.6
2	N=12 %=1.7	N=1 %=0.1	N=55 %=8.3	N=79 %=11.2
	I=6.53***	I=41.96***	I=1.07	I=0.50**
	ESTJ	ESFJ	ENFJ	ENTJ
1	N=31 %=12.3	N=4 %=1.6	N=3 %=1.2	N=15 %=6.0
2	N=13 %=1.8	N=8 %=1.1	N=27 %=3.8	N=73 %=10.4
	I=6.67***	I=1.40	I=0.31	I=0.57*

[a] Legend: % = percentof total choosing this group who fall into this type
I = self selection index; ratio of % of type in group to % in sample
* = p<.05
** = p<.01
*** = p<.001

[b] McCaulley, (1977)

HYPOTHESIS 3. There is no difference among the distribution of psychological types, as measured by the Myers-Briggs Type Indicator, among non-majors in biology and biologists (CAPT Atlas of Type Tables, 1986).

Table 26 presents the comparison of non-majors in biology with biologists. Groups that are represented significantly less in the non-major population are INTJ, INFP, and ENTJ. These data support Gable's data on Table 7, page 40. They also relate to Tables 24 and 25 in this study: that there are significant differences among non-major students who are not biology majors and science majors, either students or professional biologists. The differences are in psychological types, which Curry (1983) states is the core of a person's learning style. Hypothesis 3 is rejected.

TABLE 26

COMPARISON[a] OF NON-MAJORS IN BIOLOGY (1) (N=673) WITH BIOLOGISTS[b] (2) (N=57)

	ISTJ	ISFJ	INFJ	INTJ
1	N=49 %=7.3	N=64 %=9.5	N=16 %=2.4	N=11 %=1.6
2	N=7 %=12.3	N=3 %=5.3	N=4 %=7.0	N=5 %=8.8
	I=0.59	I=1.81	I=0.34	I=0.19**
	ISTP	ISFP	INFP	INTP
1	N=26 %=3.9	N=42 %=6.2	N=28 %=4.2	N=24 %=3.6
2	N=0 %=0	N=0 %=0	N=6 %=10.5	N=5 %=8.8
	I=0.0	I=0.0	I=0.40*	I=1.41
	ESTP	ESFP	ENFP	ENTP
1	N=42 %=6.2	N=54 %=8.0	N=83 %=12.3	N=37 %=5.5
2	N=1 %=1.8	N=2 %=3.5	N=2 %=3.5	N=4 %=7.0
	I=3.56	I=2.29	I=3.51	I=0.78
	ESTJ	ESFJ	ENFJ	ENTJ
1	N=58 %=8.6	N=73 %=10.8	N= 38 %=5.6	N=28 %=4.2
2	N=5 %=8.8	N=3 %=5.3	N=3 %=5.3	N=7 %=12.3
	I=0.98	I=2.06	I=1.07	I=0.34**

[a] Legend: % = percent of total choosing this group who fall into this type
I = self selection index; ratio of % of type in group to % in sample
* = p<.05
** = p<.01
*** = p<.001

[b] Consulting Psychologists Press. (1986)

HYPOTHESIS 4a. There is no difference in the distribution of psychological types, as measured by the Myers-Briggs Type Indicator, among the students who score 60% or greater on the computer-managed testing system and the students who score less than 60%.

Table 27 presents non-majors' achievement rank for the quarter final achievement score, by MBTI type. The numbers in the lower left hand corner of the individual types represent the achievement ranking. For example, in Table 27, INFJs' achievement was highest as indicated in the lower left by a 1, and as indicated by a grade mean for the quarter of 73%. ENTPs' achievement was lowest, as indicated by a 16 in the lower left corner and by a mean grade of 51%.

Table 28 presents frequencies of MBTI types of two populations by achievement within the non-majors in biology: students whose final cumulative test score was less than 60% and students whose final cumulative test score was equal to or greater than 60%. A chi-square analysis of the combinations of the two groups is also presented in this table.

Four groups show significant differences in MBTI type by achievement: ISTJs ($p < .05$) and ISFPs ($p < .01$) are significantly less represented among students not successful in biology, whereas both ESFP ($p < .001$)and ENTP ($p < .001$) are significantly more represented among students not successful in the non-major course, NMBC. Both of these groups occur twice as frequently in the group scoring below 60% than in the group of successful students. Therefore Hypothesis 4a is rejected.

Table 27

SUMMARY OF STUDENT MBTI TYPES BY ACHIEVEMENT

NON-MAJOR UNDERGRADUATES IN BIOLOGY

ISTJ Mean[a]=68.86 N=49 %=7.3 4[b]	ISFJ Mean=61.38 N=64 %=9.5 9	INFJ Mean=73.13 N=16 %=2.4 1	INTJ Mean=62.36 N=11 %=1.6 7
ISTP Mean=66.85 N=26 %= 3.9 5	ISFP Mean=70.71 N=42 %=6.2 2	INFP Mean= 69.25 N=28 %=4.2 3	INTP Mean=57.33 N=24 %=3.6 13
ESTP Mean=56.19 N=42 %=6.2 14	ESFP Mean=55.33 N=54 %=8.0 15	ENFP Mean=60.23 N=83 %=12.3 11	ENTP Mean=50.84 N=37 %=5.5 16
ESTJ Mean=59.02 N=58 %=8.6 12	ESFJ Mean=64.21 N=73 %=10.8 6	ENFJ Mean=60.92 N=38 %=5.6 10	ENTJ Mean=61.57 N=28 %=4.2 8

[a] mean = grade average
[b] position rank among 16 types

TABLE 28

NON-MAJOR UNDERGRADUATES IN BIOLOGY
COMPARISON* OF
STUDENTS WHOSE FINAL CUMULATIVE TEST SCORE WAS <60 (1) N=197
AND
STUDENTS WHOSE FINAL CUMULATIVE TEST SCORE WAS >=60 (2) N=476

	ISTJ	ISFJ	INFJ	INTJ
1	N=10 %=5.1	N=20 %=10.2	N=2 %=1.0	N=4 %=2.0
2	N=39 %=8.2	N=44 %=9.2	N=14 %=2.9	N=7 %=1.5
	I=0.62*	I=1.10	I=0.35	I=1.38
	ISTP	ISFP	INFP	INTP
1	N=5 %=2.5	N= 6 %=3.0	N=5 %=2.5	N=7 %=3.6
2	N=21 %=4.4	N=36 %=7.6	N=23 %=4.8	N=17 %=3.6
	I=0.58	I=0.40**	I=0.53	I=0.99
	ESTP	ESFP	ENFP	ENTP
1	N=15 %=7.6	N=23 %=11.7	N=27 %=13.7	N=18 %=9.1
2	N=77 %=5.7	N=31 %=6.5	N=56 %=11.8	N=19 %=4.0
	I=1.34	I=1.79***	I=1.16	I=2.29***
	ESTJ	ESFJ	ENFJ	ENTJ
1	N=18 %=9.1	N=18 %=9.1	N=12 %=6.1	N=7 %=3.6
2	N=40 %=8.4	N=55 %=11.6	N=26 %=5.5	N=21 %=4.4
	I=1.09	I=0.79	I=1.12	I=0.81

*Legend: % = percent of total choosing this group who fall into this type
I = self selection index; ratio of % of type in group to % in sample
* = p<.05
** = p<.01
*** = p<.001

Hypothesis 4b. There is no difference in the mean scores of learning style, as measured by the 23 subscales of the Learning Style Profile, among students whose final cumulative test score is 60% or greater and among students whose final cumulative test score for the course is 60% or greater.

Table 29 presents mean scores of the 23 subscales of the LSP and is divided into two groups: those who scored less than 60% in the course on the computer-managed test system and those who scored 60% or greater. The only subscale which showed significant differences was spatial ability (p <.01).

Course Demands

The meaning of the data presented in Table 29 can be understood more clearly if the previous data on MBTI types are held in mind. Sixty percent of the non-major population are sensing (S) types. Jensen (1987) says (Table 3, p. 35) that Ss learn best when they move from the concrete to the abstract in a step-by-step progression. It may be that the activities for learning biology do not include spatial related experiences in a step-by-step fashion adequate for the S learner to be successful.

Hypothesis 4b is rejected.

TABLE 29

LEARNING STYLES* OF NON-MAJOR UNDERGRADUATES IN BIOLOGY

Total Number of Students = 673

	Student Performance					
LSP Subscale	<60 N=197 Mean	S.D.	=>60 N=476 Mean	S.D.	t	Significance
Analytic	49	8.7	51	7.9	-1.7	NS
Spatial	51	12.6	55	11.9	-3.9	**
Discrimination	45	11.5	47	10.8	-1.3	NS
Categorization	57	7.5	57	7.7	0.2	NS
Sequent'l Proces.	54	5.3	54	5.5	-0.5	NS
Memory	46	11.2	47	10.7	-1.0	NS
Visual	53	10.2	55	10.8	-0.9	NS
Auditory	44	9.2	45	9.5	-0.2	NS
Emotive	50	10.1	49	10.2	1.7	NS
Persistence	48	8.7	49	9.8	0.1	NS
Verbal Risk	48	9.3	49	9.1	-0.9	NS
Manipulative	48	9.8	48	10.2	-1.1	NS
Early Morning	51	9.1	51	9.7	0.2	NS
Late Morning	50	9.2	50	9.4	0.7	NS
Afternoon	51	8.5	50	9.1	1.2	NS
Evening	52	8.8	53	9.2	-1.7	NS
Verbal-Spatial	48	7.4	48	7.0	0.5	NS
Grouping	41	6.5	42	6.8	-0.9	NS
Posture	55	9.7	55	10.1	0.7	NS
Mobility	48	10.1	48	9.4	-0.2	NS
Sound	44	8.8	44	9.1	1.0	NS
Lighting	52	10.5	52	9.7	0.3	NS
Temperature	54	10.1	53	10.2	0.6	NS

*Standard scores of students in Biology 110 at The Ohio State University who took both the Learning Style Profile (National Association of Secondary School Principals) and the Myers-Briggs Type Indicator (Consulting Psychologists Press)

**$p<0.01$

Table 30 presents type frequencies of those students who attended class until the second week but who never tested on the computer-managed test system; i.e., they dropped the course. Two-thirds of the students are represented in the bottom half of the type table, the extroverts. Another 63% are represented by the sensing section. These data are presented to help understand which types may be threatened by an autotutorial science course for non-majors. These students all stayed in the course into the second week, when the MBTI had to be returned, but their computer record shows no effort at testing, not even one try. There are 59% F types. These data are interesting, and again demonstrate that the ESF_ learner may be at risk in the course. (Table 28 showed that the ESFP type is almost twice as likely to score below 60%.)

TABLE 30

NON-MAJOR UNDERGRADUATES IN BIOLOGY, STUDENTS WHO ATTENDED THROUGH THE SECOND WEEK BUT NEVER TESTED ON THE COMPUTER-MANAGED TESTING SYSTEM, BY MBTI TYPE

N=27

ISTJ N=2 %=7.4	ISFJ N=4 %=14.8	INFJ N=1 %=3.7	INTJ
ISTP	ISFP N=1 %=3.7	INFP	INTP N=1 %=3.7
ESTP N=5 %=18.5	ESFP N=2 %=7.4	ENFP N=4 %=14.8	ENTP
ESTJ N=1 %=3.7	ESFJ N=2 %=7.4	ENFJ N=2 %=7.4	ENTJ N=2 %=7.4

HYPOTHESIS 5. There is no relationship between a student's score in cognitive processing skills, as measured by the Learning Style Profile, and the student's score on a question which is perceived to demand that skill.

There are over 20,000 test items in the computer-managed test bank for the NMBC in the Phoenix System. The questions are keyed to the unit objectives (Appendix E) and consist of three types, called low, high, and Image. "Low" type questions are meant to be recall (per the Associate Coordinator of the course). "High" type questions are meant to require a higher level of difficulty than recall, possibly analysis or application. "Image" type questions require the student to refer to the visuals book located adjacent to the computer terminal where the student takes tests. The "Image" type questions are, in effect, either laboratory practical type questions or diagram identification. (See Figure 5: Visual H-4 in Appendix L.)

It was decided to select questions on units G (genetics) and H (reproduction) for the following reasons: Unit H was selected because, from the beginning of the needs analysis in 1986, it had been determined that Unit H was the unit in which students scored the lowest on tests. Unit H has undergone scrutiny of individual questions (external to this study), including item analyses, since 1986. Many questions have been revised. Concentration on Unit H was considered to be in line with improvement efforts, department wide. Unit G was chosen because of the need to find questions which elicited the cognitive process, analysis, one of the skills (analytic) measured by the LSP. Some genetics problems require computations. To insure selection of questions which require the cognitive skill of analysis, this researcher chose some questions from Unit G.

Many objectives in the test bank are tested by multiple questions; many others have only a few questions per objective. Objectives from which to draw questions were systematically selected from the two units in order to obtain questions from each type of question classification. Since the number of questions per objective varies (range 2-29), some questions in the test bank are presented to each student and some probably are presented to only a few. Therefore, questions were selected from each classification type (Low, High, and Image) and from objectives with few questions and with many questions.

Fifty-eight questions were thus selected to be rated according to cognitive processes required to answer the question. Three raters used a form developed specifically for this task (Appendix L). The raters included this researcher, the Associate Coordinator, and the Assistant Coordinator of the NMBC. Both coordinators have master's degrees in biology. For each question rated, the raters responded as to what level (on a scale of 0-4) of cognitive process was required, in their judgement, to answer the question. An attempt was made to identify at least five questions per process (analytic, spatial, discrimination, categorization, sequential processing, and memory). However, two problems emerged which reduced the number of questions evaluated: 1.) inter-rater reliability was low, 2.) all questions required many processes; there were none that required only analysis, for example.

Six questions for which there was unanimous agreement as to the cognitive processes required were then selected for a preliminary test to determine if this line of inquiry might be productive, given the problems listed above. For example, if a question had a zero total, then all raters evaluated that question as having no analytic skill requirement. If a question had a score of 12, then all raters had given the question the highest possible rating (4). These extremes, low analytic and high analytic, were selected to perform a test of significance.

The next step was to identify which students were presented those questions and to identify whether or not the student answered correctly or incorrectly. This list of questions was given to staff at the Center for Teaching Excellence. A systems programmer returned a master list providing exact identification of which student, by name and computer sign-on number, was presented each of the questions evaluated by the three raters. This master list of questions, identified initially by student sign-on number, was used to select the student learning style profiles for comparison and analysis. The goal was to determine if there is congruence between a student's skill level in analysis, as measured by the LSP, and the student's ability to answer questions which require that skill. A set of hypotheses subordinate to hypothesis 5 are discussed below.

An analysis of variance was performed to evaluate cognitive process requirements of questions in the computer-managed test bank and the relationship of cognitive process requirements and cognitive process scores of students.

COGNITIVE PROCESS ANALYSIS OF THE TEST QUESTIONS

The data from these comparisons are presented in Tables 31 and 32. Six questions from the computer-managed test bank were analyzed. Two questions each were from each of types low, high, and image. Two rating levels, high (value of 12 which consisted of a score of 4 from each of 3 raters), and low (value of 0), which consisted of a score of 0 from each of 3 raters) were evaluated.

Eight different students per cell, for a total of 96 students, were randomly identified, as described above, from the computer-managed testing records for each of the six questions. The record of performance (right or wrong) for each student on each question was analyzed and is presented in Table 31.

An analysis of variance was performed on the question data by cognitive process rating (Table 32). Two each of type low, high and image questions were evaluated: those which required high analytic skill (12) and were unanimously rated, and those which required low analytic skill (0) and were unanimously rated. Two groups of students who had been asked these questions were formed: those who answered correctly and those who answered incorrectly.

No significant differences were found (see Table 32) of those students' analytical scores from the analytic subscale of the Learning Style Profile based on any one of the three major variables (question level of difficulty, amount of analytic ability required as determined by ratings of three different persons, or right/wrong answer). No significant differences were found in two factor interactions or three factor interactions. There were no significant differences based on the analytic score measured by the Learning Style Profile. Therefore, hypothesis 5 could not be rejected for the five items analytic scale proposed by the NASSP. (See Factor Analysis and subsequent ANOVA.)

TABLE 31

LEARNING STYLE PROFILE FIVE ITEM ANALYTIC SCORE QUESTION ANALYSIS

Analytic Subscale = five items (25, 26, 27, 28, 29)

Question Type	[B] High Analytic		Low Analytic	
	Correct	Incorrect	Correct	Incorrect
Low	Mean* 51.63 S.D. 6.80	Mean 46.75 S.D. 8.29	Mean 44.13 S.D. 9.48	Mean 49.13 S.D. 6.96
[A] High	Mean 50.63 S.D. 11.35	Mean 50.75 S.D 5.97	Mean 49.13 S.D. 6.96	Mean 48.13 S.D. 9.23
Image	Mean 50.63 S.D. 9.43	Mean 49.25 S.D. 7.85	Mean 53.25 S.D. 7.08	Mean 49.13 S.D. 9.40

*LSP analytic subscale standard score for eight SS/cell, all different

TABLE 32

ANALYSIS OF VARIANCE OF QUESTION TYPE, AMOUNT OF ANALYSIS (FIVE ITEMS), AND CORRECT VS INCORRECT RESPONSE TO MULTIPLE CHOICE TEST QUESTIONS

Analytic Subscale = five items (25, 26, 27, 28, 29)

Source		Sum of Squares	Degrees of Freedom	F	P value
Question Type	(A)	116.69	2	0.83	0.44
High versus Low analysis required	(B)	30.38	1	0.43	0.51
Correct vs incorrect response^R	(C)	26.04	1	0.37	0.55
AB		68.69	2	0.49	0.62
AC		36.02	2	0.25	0.78
BC		24.00	1	0.34	0.56
ABC		188.69	2	1.34	0.27
Error		5884.0	84		

In the three-factor analysis of the LSP five item analytic scores in which the first factor was question type, the second factor was high versus low analytic requirement, and the third factor was correct or incorrect response. There were no major effects, two factor interactions nor a three factor interaction, as shown in Table 32.

An additional analyses of variance was performed on the same group of 96 students, as explained following the results of factor analysis presented next.

FACTOR ANALYSIS

Kim & Mueller (1978, p.8) describe factor analysis as the assumption that observed variables are linear combinations of some underlying factors, some of which are assumed to be common to two or more variables and some of which are assumed to be unique to each variable. The unique factors are then assumed to be orthogonal to each other and do not then contribute to the covariance between variables. Only the common factors contribute to the covariation among the observed variables.

The linear system assumed in factor analysis, according to Kim & Mueller, is such that one can identify the resulting covariance structure without error if the underlying factor loadings are known. Covariance measures the extent to which values of one variable tend to covary with values of another variable. Covariance is actually Pearson's product-moment correlation coefficient. Kim & Mueller (1978, p. 10) list three steps used by researchers to obtain factor analytic solutions: 1.) preparation of a covariance matrix; 2.) extraction of initial (orthogonal factors; and 3.) rotation to a terminal solution.

Since the LSP had never been administered to a college population and no normative data existed, prior to this study, factor analysis was chosen to attempt to add validity to the use of the instrument for older adolescents and adults. Several factor analyses were attempted, including one exactly like that described in the Technical Manual for the LSP, a 19 factor solution.

The factor analysis results presented in Appendix N are the closest attempt to the NASSP 19 factor solution. The principal component method of factor analysis was used followed by varimax rotation. Following the NASSP factor solution, all items contributing to the perceptual modality preferences of visual, auditory and emotive subscales, as well as the categorization variables, were removed.

Table 33 presents the results from a nine factor solution, varimax rotation, which yielded a six item factor loading on the LSP variable analytic subscale. Table 34 presents the factor standard regression coefficients of all items which loaded with the analytic factor. Two items from the spatial subscale (37 and 40) loaded with the analytic items. The reliability of this six item analytic scale was 0.645. Items which loaded with analytic items are presented in Appendix N, along with the standard regression coefficients for the 19 factor solution.

Following the six item loading of the analytic scale, an additional analyses of variance test was performed on the same 96 students presented in Tables 31 and 32. A reanalysis of student answers based on an analytic scale composed of the six items which loaded together in the 9-factor solution and presented in Table 33 and 34. The reanalyses data are presented in Tables 35 and 36.

Because no standard scores were available for this newly created subscale on the LSP, raw scores were used and the data were transformed using a square root transformation. Transformations are frequently done when data are not as continuous as desired.

On this analysis, presented in Tables 35 and 36, a signficant three factor interaction was found when the data were transformed. There is a significant interaction between question level, amount of analysis required and whether or not the student answered the question right or wrong ($p < .04$).

The three factor interaction is difficult to interpret but a sense of the interactions can be obtained from an examination of the means shown in Table 35. Generally, with A and B held constant and looking at mean scores of correct vs incorrect, the incorrect is generally lower

TABLE 33

FACTOR ANALYSIS OF LEARNING STYLE PROFILE

Factor Name	Eigen Value	Percent Variance	Cumulative Percent Variance
1. Persistence	4.19	.11	.11
2. Sound	3.61	.09	.20
3. Study Time-- Evening	3.01	.08	.28
4. Lighting	2.71	.07	.35
5. Grouping	2.50	.06	.41
6. Temperature	2.44	.06	.48
7. Manipulative	2.24	.06	.53
8. Analytic	1.96	.05	.59
9.	1.72	.04	.63

TABLE 34

ANALYTIC FACTOR COMPONENTS

Item Number	Standard Regression Coefficient
25	.50
27	.44
28	.63
29	.53
37	.36
40	.35

TABLE 35

LEARNING STYLE PROFILE SIX ITEM ANALYTIC SCORE QUESTION ANALYSIS (square root transformation)
Analytic Subscale=six items (25, 27, 28, 29, 37, 40)

Question Type		[B] High Analytic		Low Analytic	
		Correct	Incorrect	Correct	Incorrect
Low	Mean[a] / Mean	2.11	1.45	1.75	2.01
	S.D.	.25	.93	.58	.30
[A] High	Mean	2.02	1.94	2.01	1.90
	S.D.	.45	.35	.33	.55
Image	Mean	2.06	2.01	2.24	1.98
	S.D.	.36	.27	.35	.48

[a] LSP analytic subscale raw score for eight SS/cell, all different

TABLE 36

ANALYSIS OF VARIANCE OF QUESTION TYPE, AMOUNT ANALYSIS, (SIX ITEMS), AND CORRECT VS INCORRECT RESPONSE TO MULTIPLE CHOICE TEST QUESTIONS (square root transformation)
Analytic Subscale = six items (25, 27, 28, 29, 37, 40)

Source		Sum of Squares	Degrees of Freedom	F	P value
Question Type	(A)	0.95	2	2.15	0.12
High versus Low analysis required	(B)	0.06	1	0.26	0.61
Correct vs incorrect response	(C)	0.53	1	2.41	0.12
AB		0.07	2	0.16	0.85
AC		0.05	2	0.11	0.90
BC		0.30	1	1.36	0.25
ABC		1.45	2	3.28	0.04
Error		18.57	84		
Total		21.98	95		

except for low level questions and low amount of analysis. Students who missed high analytic questions from the low cognitive level set had lower LSP analytic scores than those answering correctly. Students who missed the low analytic questions from the low cognitive level set had higher LSP analytic scores than those answering correctly.

All cells A x B x C are basically the same except for 1) low question type x high analytic x incorrect (low LSP score of 1.45) 2) low question type x low analytic x correct (low LSP score of 1.75).

It is not unexpected that those with low LSP analytic scores should be less successful on high analyic questions. It is less obvious why those with low LSP scores should be more successful on low analytic questions. Perhaps the use of analytic skills on low level recall items results in confusion or misinterpretation. Students may read more into the question than is expected or may refuse to memorize material.

Since a three-way interaction between question type, high vs low analytic requirement, and correct vs incorrect response was found, hypothesis five is rejected for analytic ability. Hypothesis five could be rejected for the other five cognitive processes.

HYPOTHESIS 6. There is no predictive ability of the Myers-Briggs Type Indicator, as described by Curry (1983), in determining a student's learning style as measured by the Learning Style Profile.

PEARSON CORRELATION COEFFICIENT MATRIX

Correlation coefficients were determined using the SAS procedure, PROC CORR, for all LSP, MBTI and performance scores. Table 37 displays the correlation matrix for the 558 students who took both the LSP and the MBTI and for whom there were no missing values. No students had missing values on the MBTI; only 20 students omitted 20 or more items on the 126 items of the LSP. The 100 students deleted from the data set had only 1 or 2 items missing on the LSP. However, all of them (115) were deleted for all of the rest of the data analysis.

The MBTI individual dimensions (E,I,S,N,T,F,J,P) are correlated with each of the 23 LSP subscales on Table 37. Final cumulative performance score is in the matrix as well. Correlations greater than 0.05 significance level have been listed. Because the number of variables is 32, only the ones greater than 0.002 will be discussed. The others are listed because, even at the levels of correlation and significance listed, they are of interest in the analysis of relationships between learning style measures. The significance levels greater than 0.0001 are designated on Table 37 by four stars (*).

The most significant correlate on the table is the LSP subscale, verbal risk. Verbal risk has a positive correlation at the 0.0001 level with extroversion (.30) and intuition (.25). Verbal risk correlates negatively with sensing (-.28), introversion (-.33) and feeling (-.17), all at the 0.0001 level of significance.

The LSP persistence subscale correlates positively with judging (.17) and negatively with perceiving (-.21), both at the 0.0001 significance level. The manipulative subscale correlates positively (.17) with thinking. Mobility preference positively correlates with perceiving (.20), and negatively with judging (-.19), both at the 0.0001 significance level. Finally, performance in the course correlates (.23) at a probability significance level of 0.0001 with spatial ability.

Table 37

CORRELATION COEFFICIENTS MATRIX
OF LEARNING STYLE PROFILE SUBSCALES
AND MYERS-BRIGGS TYPE INDICATOR DIMENSIONS
(N=558)

Learning Style	Myers-Briggs Type Indicator Dimensions#								
Profile Subscales	E	I	S	N	T	F	J	P	Performance
Analytic	-.09*								.13**
Spatial									.23****
Discrimination			.11**	-.09*					
Categorization	-.12**	.12**							
Sequent'l Processing									
Memory						.08*	-.1*	.12**	
Visual									
Auditory									
Emotive			-.09*	-.1*					
Persistence			-.11*		.10*	-.15***	.17****	-.21****	
Verbal Risk	.30****	-.33****	-.28****	.25****	.15***	-.17****		.10*	
Manipulative			-.14***	.13***	.17****	-.13***			
Early Morning	-.09*	.08*					.09*	-.10*	
Late Morning							.14*	-.14*	
Afternoon							.10*	-.11**	
Evening	.09*	-.09*							
Verbal-Spatial									
Grouping				.09*					
Posture			.16***	-.10*	.08*	-.10*	.14**	-.14***	
Mobility					-.10*	.14***	-.19****	.20****	
Sound			-.12**	.12**			-.16***	.15***	
Lighting									
Temperature			.12**	-.11**	-.10*	-.11**			

#Legend:
- * = p<.05
- ** = p<.01
- *** = p<.001
- **** = p<.0001

CANONICAL CORRELATION

Canonical correlation is a procedure for investigating the relationship between two sets of variables. The general question addressed by canonical correlation is: to what extent can one set of variables be explained or predicted by another set of variables? (Thompson, 1984). The analysis collapses the scores for each set of variables in a set into a single composite variable. Composite scores derived are then called variate scores. The linear combinations are referred to as canonical variates (Kennedy, 1988, personal communication).

The bivariate correlation (Pearson product-moment correlation) between the two composite scores, one from each of the two variable sets, is the canonical correlation coefficient. The first pair of linear combinations (canonical variates) yields the highest possible canonical correlation coefficient for a set of data.

After this first canonical correlation is obtained, additional canonical correlation coefficients are calculated which are independent of the first; i.e., the second canonical correlation is based on linear combinations of the sets of variables independent of the correlations in the first canonical correlation set. Subsequent correlations can be made in a similar manner, all in decreasing orders of magnitude.

Structure coefficients are product-moment correlations between the original variables and the canonical (composite) score. Generally, a structure coefficient equal to or greater than .30 is treated as meaningful. These structure coefficients are used to name the canonical variates in this way, in terms of the variables that have meaningful loadings [structure coefficients equal to or greater than .30 on the particular canonical variate (Warmbrod, 1987, p. 2)].

Table 38 presents the results of canonical correlation for the LSP and MBTI variables. The first, and highest possible,correlation between the two sets of variables is .49. The variable with a loading above .30 is, in the LSP subscales, verbal risk (.42). Verbal risk explains the first canonical variate, or contributes most to the correlation between the two sets of variables.

The squared canonical correlation (R^2) for the first canonical variate is .24. This is interpreted to mean that 24% of the variance in the verbal risk score on the LSP could be predicted from MBTI scores. It also could mean that verbal risk contributes the most from the group of LSP variables to the relationship between the two groups of variables - LSP and MBTI. Likewise, the variables Judging, Perceiving and Introversion from the MBTI group of variables contribute the most to the relationship between the two groups of variable - LSP and MBTI.

TABLE 38

CANONICAL CORRELATION (CC) OF LEARNING STYLE PROFILE VARIABLES WITH MYERS-BRIGGS TYPE INDICATOR VARIABLES

N=558

23 LSP Variables with 8 MBTI Dimensions

	Canonical Correlation (CC)	Squared Can. Correlation
1st CC	.49	.24
2nd CC	.44	.19

Variables Contributing to

	1st CC		2nd CC	
LSP	verbal risk	.42	persistence	.24
			memory	.13
			manipulative	.12
			evening study time	.13
MBTI	judging	.12	judging	.13
	perceiving	.14	perceiving	.23
	introversion	.11		

Wilks' Lambda	.45	p< .0001
Pillai's Trace	.74	p< .0001
Hotelling-Lawley Trace	.89	p< .0001
Roy's greatest root	.32	p< .0001

The second canonical correlation (.44) is more difficult to interpret. There are four subscales on the LSP which contribute to the relationship between the LSP and MBTI and which can be predicted from the MBTI. Likewise, there are two aspects of one MBTI dimension that contribute to the relationship between the LSP and MBTI. Judging and perceiving are important and have more than one aspect involved. Some aspects of judging and perceiving are related to the first canonical correlation and some to the second canonical correlation.

Because the groups of variables are related and can be predicted from one another, in this case the LSP from the MBTI, hypothesis 6 is rejected. Hypothesis 6 is rejected for verbal risk. Hypothesis 6 cannot be rejected for all other subscales in the LSP.

LOGISTIC REGRESSION

Petersen (1989, p. 130) decribes logistic regression as a logit model, used often in sociological research in order to relate a dichotomous dependent variable to a set of independent variables. Resultant statistics from this logit model include predicted probabilities of belonging to one of the categories on the dependent variable. These statistics help convey the significance of the reported results (Nabor, 1989, personal communication; Wood, 1989, personal communication).

Stepwise, forward and backward, logistic regression was performed on variables in the LSP and MBTI. Selected variables were chosen, as well, for separate logistic regression. These variables were chosen because of their identification in previous statistical tests. All logistic regressions used the PROC LOGIST procedure in the SAS programming language. Stepwise, forward and backward, was chosen in the event that variables which were selected did not include variables which could have predictive value.

Information to guide the regression analyses were the chi-square tests of the MBTI data, Pearson correlation coefficients, and canonical correlation. Logistic regression was chosen because 1.) the distribution of the dependent variable, performance score as measured by the computer-managed testing system, was not normally distributed, and 2.) Pass/fail criteria was selected as an important criterion in discriminating between students who were successful and those who were not. Only 27 of the students in the sample dropped the course without trying the computer-managed testing system. These students, including the rest who scored below 60%, compose the fail group. The pass group includes students who scored 60% or higher.

Variables were entered into stepwise regression analyses using the final performance score as the dependent variable. All LSP and MBTI variables were placed in the model. Previous statistical analysis had identified variables of interest; these were analytic skill, spatial skill, extraversion, introversion, judging, and perceiving.

The results from the logistic regression are presented in Table 39. The logistic regression kept only the spatial skill and introversion in the model, in both the stepwise and the selected variables procedure. The predictive power is R=0.18, a value similar to explained variance in multiple regression. Converting that logarithmic value to a probability model, however (as demonstrated in Table 39), a probability of predicting a performance score less than or greater than or equal to 60 is .67, if the spatial skill score and the introversion score are known. A pseudo R^2 value of .53 has been calculated from the likelihood ratio statistic.

TABLE 39

STEPWISE LOGISTIC REGRESSION: INTROVERSION AND SPATIAL SKILL VS PERFORMANCE

Categorical Dependent V = Performance Score <60 N=158
Performance Score >= 60 N=400

Variable	Beta (Logits)	St. Er.	Chi-Sq	P	R
Intercept.	-1.005	.44	5.29	.02	
Spatial Skill	.0249	.01	11.17	.0008	.12
Introversion	.0546	.02	12.24	.0005	.12

Predictive Probabilities

$L = 1N\ [P/1-P)]$

L = Logit
1N = Natural logarithm
P = Probability

$$\text{Log}\ \frac{P}{1-P} = (-1.005) + (.0249)\ \begin{matrix}\text{spatial}\\ \text{skill}\\ \text{value}\end{matrix} + .0546\ \begin{matrix}\text{Intro-}\\ \text{version}\\ \text{value}\end{matrix}$$

Example: Spatial Skill mean value = 3.6
Introversion mean value = 11.54

Probability of having a score = 60 =

$$=(-1.005)+(.0249)\ (3.6)+(.0546)\ (11.54)=.7197$$

$$= \frac{e\ .7197}{1+e^{.7197}} = \frac{2.0539}{3.0539}$$

Probability = .6725

Meaning: if spatial skill and introversion values are known, the probability of correctly predicting a performance score >60 or <60 is .6725.

$$\text{Pseudo } R^2 = \frac{\begin{matrix}\text{Pseudo } R^2\\ \text{Likelihood Ratio Statistic (LRS)}\end{matrix}}{N + LRS}$$

LRS=640.26
N = 558

$$= \frac{640.26}{558 + 640.26} = .53$$

It is concluded that knowing certain dimensions of learning style can predict achievement in the NMBC ($p < .0005$). This result is in agreement with rejection of hypothesis 4b; there is a relationship between the learning style subscale of spatial ability and success in the NMBC. The results also support rejection of hypothysis 4a; i.e., there is a relationship between the learning style of introversion and success in the NMBC.

FINDINGS

1. Differences were found between the 12th grade and non-majors in biology on the following LSP subscales. Non-majors scored higher in spatial and sequential processing skills, visual perceptual modality, persistence orientation, evening study time, formal posture preference, and bright lighting preference. Twelfth graders scored higher in memory skill, auditory perceptual modality, verbal risk orientation, late morning study time preference, mobility, and sound preferences ($p < .0001$) (Table 16).
2. INTJs and INFPs are less represented in the non-majors than in majors in biology ($p < .05$) (Table 24).
3. The following types are less represented in the male non-majors than in the male majors in science: INTJ, INTP

($p < .001$); ENTP ($p < .01$); and ENTJ ($p < .05$) (Table 25).

4. The following types are more represented in the male non-majors than in the male majors in science: ISTJ, ISFJ ($p < .01$); ISTP, ISFP, ESTP, ESFP and ESTJ ($p < .001$) (Table 25).
5. The following types are less represented in the non-majors than in biologists: INTJs ($p < .01$), INFPs ($p < .05$), and ENTJs ($p <.05$) (Table 26).
6. The following types are less represented among students not successful in biology for non-majors: ISTJs ($p < .05$) and ISFPs ($p < .01$) (Table 28).
7. The following types are more represented among students not successful in biology for non-majors: ESFPs and ENTPs ($p < .001$) (Table 28).
8. Among students who score less than 60% in the NMBC, spatial skill, is lower than among students who score higher than or equal to 60% ($p < .01$) (Table 29). Performance in biology correlates at the 0.23 level (correlation coefficient) with spatial skill on the LSP ($p < .0001$) (Table 37).
9. Question type, amount of analytic skill required, and correct vs incorrect answers interact with a six item analytic scale on the LSP (Table 35, $p < .04$).

10. Persistence orientation correlates positively (0.17) with Judging ($p < .0001$) (Table 37).
11. Persistence orientation correlates negatively (-0.21) with Perceiving ($p < .0001$) (Table 37).
12. Verbal risk preference correlates positively with Extraversion (0.30) and Intuition (0.25) ($p < .0001$) (Table 37).
13. Verbal risk preference correlates negatively with Introversion (-0.28), and Feeling (-0.17) ($p < .0001$) (Table 37).
14. Manipulative preference correlates positively with Thinking (.17) ($p < .0001$) (Table 37).
15. Mobility preference correlates negatively (-0.19) with Judging ($p < .0001$) (Table 37).
16. Mobility preference correlates positively (.20) with Perception ($p < .0001$) (Table 37).
17. There is a canonical correlation of 0.49 between the two sets of LSP and MBTI variables ($p < .0001$) (Table 38).
18. The verbal risk orientation subscale on the LSP composes most of the contribution to the relationship between the LSP and the MBTI (Table 39). Verbal risk can be predicted from MBTI scores (0.24) ($p < .0001$) (Table 39).
19. In the second canonical correlation, from the LSP, persistence, memory, manipulative and evening study time contribute to the relationship between the LSP and the

MBTI. Judging (J) and Perceiving (P) contribute from the MBTI to the relationship.

20. Spatial skill (p < .0008) and Introversion (p < .0005) predict success in the NMBC (Table 39). Introversion (p < .0005) and spatial (p < .0008) skill (p < .0008) correlate (R=.67) with biology achievement (Table 39).

A trend of interest is the large number of male non-majors who are perceiving (P) (56.7%, Table 19, p. 86), as compared to the general population figure of McCaulley et al, 1985 (42.7%, Table 21, p. 86).

TABLE 40

SUMMARY OF GROUP FINDINGS FOR LEARNING STYLE PROFILE

LSP Subscale	Greater Group LSP Score		Lesser Group LSP Score
Spatial Skill	Non-majors	>[a]	12th Graders
Sequential processing skill	Non-majors	>	12th Graders
Visual perceptual modality	Non-majors	>	12th Graders
Persistence orientation	Non-majors	>	12th Graders
Evening study time preference	Non-majors	>	12th Graders
Formal posture preference	Non-majors	>	12th Graders
Bright lighting preference	Non-majors	>	12th Graders
Memory skill	12th Graders	>	Non-majors
Auditory perceptual modality	12th Graders	>	Non-majors
Verbal risk orientation	12th Graders	>	Non-majors
Late morning study time preference	12th Graders	>	Non-majors
Verbal spatial preference	12th Graders	>	Non-majors
Mobility preference	12th Graders	>	Non-majors
(More) sound preference	12th Graders	>	Non-majors

[a] $p < .0001$

Biology Achievement

Spatial skill[b]	successful	>	non-successful

[b] $p < .01$

TABLE 41

SUMMARY OF GROUP FINDINGS FOR MYERS-BRIGGS TYPE INDICATOR

MBTI Type	Greater Group		Lesser Group	P Value
INTJ	Biology majors	>	Non-majors	.05
INFP	Biology majors	>	Non-majors	.05
INTJ	Male science majors	>	Male non-majors	.001
INTP	Male science majors	>	Male non-majors	.001
ENTP	Male science majors	>	Male non-majors	.01
ENTJ	Male science majors	>	Male non-majors	.05
ISTJ	Male non-majo	>	Male science major	.01
ISFJ	Male non-major	>	Male science major	.01
ISTP	Male non-major	>	Male science major	.001
ISFP	Male non-major	>	Male science major	.001
ESTP	Male non-major	>	Male science major	.001
ESFP	Male non-major	>	Male science major	.001
ESTJ	Male non-major	>	Male science major	.001
INTJ	Biologists	>	Non-majors	.01
INFP	Biologists	>	Non-majors	.05
ENTJ	Biologists	>	Non-majors	.05

Biology Achievement

ISTJ	Successful	>	Non-successful	.05
ISFP	Successful	>	Non-successful	.01
ESFP	Non-successful	>	Successful	.001
ENTP	Non-successful	>	Successful	.001

CHAPTER V

CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS

This chapter presents the purpose of the study and the findings. It also includes:

1. conclusions
2. implications and recommendations for course improvement based on the findings
3. implications and recommendations for future research based on the findings.

THE PURPOSE OF THE STUDY

The purpose of this study was to provide qualitative and quantitative information on learning characteristics of the non-major in biology, for use in course redesign, to improve the course. The course is presently taught by the audiotutorial method and has a computer-managed testing system.

The Instructional Systems Design (ISD) (McCombs, 1986) model for program development was used to guide this study, which is only a small part of biology course development, for non-majors, currently under way at The Ohio State University.

The needs analysis portion of ISD, described by McCombs (1986) and Carrier & Jonassen (1988), became the focus of the study, particularly identifying the learning characteristics of the students in the course. Carrier & Jonassen stated that identification of learner characteristics is important because of the increasing use of microcomputing technologies. In the NMBC, 92% of evaluation of learners involves computer testing.

As the study progressed, it became increasingly apparent that the ISD model could drive any reform efforts chosen to provide for appropriate science education for non-majors. This study provides empirical data of the characteristics of the non-majors enrolled in general biology, from which the other steps in the ISD model should proceed. From these data on the non-major, scientists who teach these students can know that any efforts that they make to change course format, laboratory format, and/or teaching assistant duties, are based on evidence, not conjecture. Learning style literature, explained by Claxton & Murrell (1987), emphasizes the need to use learning style in higher education. They write that student retention can be improved when attention is given to students' preference for learning.

CONCLUSIONS REGARDING THE MBTI

Findings 2-7 (pp. 130 & 131) are discussed below and are displayed on Table 42 (Table 9, p. 44, with the findings added). Table 42 is a consolidation of all findings from hypotheses 1, 2, 3, and 4a.

INTJs and INFPs are less represented in the non-majors than the biology majors (BM) population (Table 24, p. 94). INTJs, INFPs and ENTJs are less represented in the non-majors than the biologists (BG) population (Table 26, p. 100). These two findings from the data on Tables 4.13, p. 94, and 4.15, p. 100, support each other regarding the INTJs and the INFPs. These three groups (INTJs, INFPs and ENTJs) represent 10% of the total population of non- majors (Tables 18, p. 85 and 5.1).

In examining the differences between the male non-majors and the male science majors (Table 25, p. 98), the INTJs and ENTJs are present (as in biologists, Table 26, p. 100) in addition to the INTPs and the ENTPs. These data support Gable's findings (Table 7, p.40) that show research scientists as 100% NT. The data in Table 42 demonstrate that a major difference between the group of biology student non-majors is that they are not primarily NT, as are research scientists as reported by Gable (Table 7, p.40). In all four NT groups, non-majors are less represented than science majors.

TABLE 42

MBTI FREQUENCY DISTRIBUTION FINDINGS:
COMPARISON OF NON-MAJORS, MALE SCIENCE MAJORS,
BIOLOGY MAJORS, BIOLOGISTS,
AND STUDENTS WHO FAIL
N=673

ISTJ **Less who FAIL** F=18 M=31**More than MSM** N=49 %=7.3	ISFJ F=51 M=11**More than MSM** N=64 %=9.5	INFJ F= 8 M= 8 N=16 %=2.4	INTJ **Less than BM,BG** F= 5 M= 6 **Less than MSM** N=11 %=1.6
ISTP F= 5 M=18**More than MSM** N=26 %=3.9	ISFP **Less who FAIL** F=22 M=19**More than MSM** N=42 %=6.2	INFP **Less than BM,BG** F=14 M=14 N=28 %=4.2	INTP F=10 M=14 **Less than MSM** N=24 %=3.6
ESTP F=13 M=28**More than MSM** N=42 %=6.2	ESFP **More who FAIL** F=39 M=15**More than MSM** N=54 %=8.0	ENFP F=58 M=21 N=83 %=12.3	ENTP **More who FAIL** F=22 M=14 **Less than MSM** N=37 %=5.5
ESTJ F=25 M=31**More than MSM** N=58 %=8.6	ESFJ F=67 M= 4 N=73 %=10.8	ENFJ F=35 M= 3 N=38 %=5.6	ENTJ **Less than BG** F=13 M=15 **Less than MSM** N=28 %=4.2

MSM=male science major
BM=biology major
BG=biologist

When non-majors are compared to the biologists, there are two NT groups and one NF group which show differences (Table 26, p. 110). Apparently, biologists are less NT than other groups of scientists. Also, apparently, non-majors are less different from biologists than from scientists (which includes other scientist groups in addition to biologists). Biology majors' and biologists' data include both male and female subjects so part of the NT difference could be gender related. Myers in McCaulley et al., 1985, (Table 20, p. 86) reports that 60% of the general population males are T. McCaulley et al., 1985 (Table 21, p. 86) report that 65% of the general population males are T.

Roberts (1982) in Table 1 (p. 15) reveals that for all of the NT community college student types (INTJ, INTP, ENTP and ENTJ), readings are a preferred medium by which to learn. Readings and audio tapes comprise instruction in the NMBC.

Groups which are more represented in the non-major population emerge from the comparison with the science majors. The most noticable difference is in the sensing (S) dimension. Seven of eight S profiles are more represented among non-majors than among science majors. This difference is astonishing, partly because it supports Gable's data on Table 7 (p. 40): that research scientists are 100% N. It is no wonder that scientists have trouble designing courses for the non-major, as Weistheimer says (1987). The non-major in science, being predominantly S, does not attend to the same kind of stimuli as a person with the N orientation (Table 3, p. 35).

Jensen's (1987) Table 3 (p. 35) shows that Ss learn best when they move from the concrete to the abstract in a step-by-step progression. Jensen's data seem to support, in part, the idea that the NMBC is ideal for S types, because the course is modular and there are computer elements to it. The computer part of the NMBC, however, is not computer-assisted instruction. It is computer-managed. Jensen states that S types like practical knowledge. The NMBC, in this researcher's opinion, however, does not focus on knowledge for practical use. Jensen also lists memorizing of facts, precision and accuracy as a preference of S types. Certainly, in the NMBC, S types are at home with memorization. Precision and accuracy are rewarded in the computer testing by the use of multiple choice test items.

The two MBTI groups not successful in the course are the ESFP and the ENTP (Table 28, p. 103). These groups are also represented in previously mentioned groups: ESFPs are more represented among the male non-majors than among male science majors, and ENTPs are less represented than male science majors (Table 25 p. 98). So as a group, since there are more of the ESFPs and they fail more frequently, their learning needs should be closely examined. Robert's (1982) Table 1

(p. 15) lists ESFP's preferred media as small group work and motion pictures/TV. The least preferred media of the ESFP are listed as programmed instruction and readings. For the ENTP, discussions and readings are the most preferred, while audio, demonstrations, and role playing are least preferred. In the NMBC, readings and audio programmed instruction is the format. For the ESFP, according to Roberts, 1982 (p. 14), the NMBC is formatted in the least preferred way, because the course is designed for the student to read and learn the material according to a structured and programmed format. Interestingly, the ESFP is one of only three groups in Robert's table who does not list audio instruction as a least preferred medium.

Campbell's study (Table 8, p.41) showed that 14 of 16 MBTI types least prefer memorization as a learning method. In Campbell's study, students were asked to rank a list of 33 different methods according to their preference for learning. All 16 MBTI types chose either "confer with other students" or "group discussion" as their most preferred learning method. Memorization and examination were least preferred in 14 of 16 MBTI groups.

IMPLICATIONS FROM THE MBTI FOR COURSE DESIGN

Robert's (1982, Table 1, p. 15) and Campbell's (1986, Table 8, p. 41) studies of adult learners show that the least favorite learning preferences are audio, memorization, and examination in 14 of 16 MBTI types. The study presented here shows that only four of the 16 MBTI types (ESFJ, INFJ, ENFP, and ENFJ) are the same in number as science majors, biology majors, or biologists; i.e., twelve of 16 MBTI types show differences in the comparison populations (Table 42, p. 139). Therefore, when biologists start to design courses for the non-major, they need to look at the research that shows what the various MBTI types prefer as learning methods. Particular attention should be paid to those types that are different from biology majors, biologists, and science majors.

In the study presented here, only the INFJ, ENFP, ESFJ, and ENFJ show no differences from the comparison populations: biology majors, science majors, biologists, or among students who were successful vs non-successful ones.

The greatest differences occurred in the left half of the type table, among students who prefer sensing (S) perception. Biology non-major course designers can examine Jensen's (1987) table (2.1, p. 35) and the tables of Roberts (1982, Table 1, p. 15) and Campbell (1986, Table 8, p. 41) for ideas for learning method preference for possible course improvement.

According to Roberts (1982, Table 1, p. 15), small group work is the most preferred learning method of the ESFP. The ESFP male non-major in biology is the most different (Table 25, p. 98) from male science majors and one of two groups (male and female) in the NMBC that most frequently fails the course (Table 28, p. 103).

RECOMMENDATIONS FROM THE MBTI FOR COURSE DESIGN

1. Because more sensing (S) students (Table 19, p. 86: 60.6%), than intuitive (N) (39.4%) students are represented in courses for non-majors in biology in this study, it is desirable to provide learning methods that this type of student prefers. Methods suggested by Jensen (1987, Table 3, p. 35) include programmed instruction, computer-assisted instruction and learning for practical knowledge. The NMBC already includes programmed instruction.
2. Because there are more (61.4%) extroverts (E) than introverts (I) (38.6%) among non-majors (Table 19, p. 86), provide learning opportunities for them which Jensen (1987, Table 3, p. 35) says they prefer. Those preferences, listed by Jensen, include: learning situations filled with movement, action, and talk.

These situations should be connected with their experience via group discussion or cooperative projects.

CONCLUSIONS REGARDING THE LSP

The differences found between the 12th grade population, reported by the NASSP, and the non-majors in biology could be, in part, developmental and preferential. In some cases, results seem contradictory.

Twelfth grade high school students score higher on memory skill, supposedly a developmental task. Campbell's (1986, Table 8, p. 41) data were from persons in the Air Force so they support older learners' least preference in learning as memorization. It could be that older learners (older than 12th grade), such as those in the NMBC, lack of a preference for memorization is demonstrated by low skill scores on the LSP. Perhaps older learners have such strong learning preferences which do not include memorization that the preference overrides the development. That is, perhaps they have equal skill development, but their preference for non-memory type learning methods is demonstrated by strength in other preference scores. Their development may be equal in memory skill to twelfth graders, but their preferences in other learning methods may diminish their score. It could happen that use of a more preferred method, such as visual, may diminish a previously developed skill, such as memory. Older learners (older than twelfth graders) have had more time to exercise their preferences for learning methods. It may be that with time and experience of exercising a learning preference, a skill such as memorizing can become less developed.

Twelfth graders show preference for auditory instruction, in contrast to the NMBC students. These data, coupled with the NMBC student preference for visual instructional preference, support Roberts' findings (1982, Table 1, p. 15), that 14 of 16 MBTI types of community college students least prefer audio instruction.

Twelfth graders' verbal risk orientation is no longer evident in college students. They show study time preferences of late morning vs NMBC students' preference for evening. Twelfth graders like to move around (mobility) and prefer more sound in a study setting than do non-majors in biology, who prefer a formal and well lit study setting.

The pre-college student is less skilled than the undergraduate non-major in biology in spatial and sequential processing. Both of these skills are presumably developmental. Persistence is higher in college students, which could indicate that high school students who do not have a persistence orientation do not make it to college. Thirteen of the subscales show differences between the twelfth grade students and NMBC students. What is surprising is the lack of significant differences among these two populations on the other ten subscales, particularly analytic and discrimination skills. The fact that there are 13 differences may have implication for course design.

Analytic Skill Cognitive Demand

The five item subscale on the LSP which measured analytic skill did not show any relationship to a student's performance on six questions perceived by three raters to require that skill (Tables 31 and 32, p. 113). The interpretation of this result is problematic because the raters had no formal training in evaluation of questions by cognitive demand. Therefore, the lack of relationship could be attributed to rater evaluation error, rather than to lack of congruence between a student's score on analytic skill on the LSP and that student's subsequent ability to answer a question commensurate with that measured skill. Also, the sample of 96 students was small, and only six questions were evaluated.

Because the five item analytic subscale on the LSP did not show any relationship between a student's score on analytic skill and subsequent performance on a question which was perceived to require that skill, additional analysis was performed using a six item subscale. The reliability for the six-item analysis was 0.645, which is slightly higher than the five item analytic subscale of 0.64. The rationale for this subsequent analysis was based on factor analytic results presented in Table 33, p. 117.

The six item analytic subscale (Tables 35 and 36, p. 118) shows a three factor interaction, which suggests that there is a relationship between a measured amount of analytic skill (if a different and improved analytic subscale is used) and a student's ability to perform on questions which are perceived to require analytic skill. These data may support part of Tobias' (1982) claim (p. 16) that engagement of appropriate cognitive processes makes the difference in learning.

IMPLICATIONS FROM THE LSP FOR COURSE DESIGN

Standard scores (Table 17, p. 83) for students in the NMBC show below average skill in discrimination and memory. NMBC students most prefer visual learning and least prefer instruction by the auditory method. These data support Roberts' (1982, Table 1, p. 15) and Campbell's (1986, Table 8, p. 41) data.

Orientations (persistence, verbal risk, and manipulative) are all below-average, which could indicate lack of interest or motivation to study biology. McCaulley (1977) says the difficulty in designing courses for non-majors lies in differences between science non-majors and science majors in motivation, interest, and learning style. Persistence could be viewed as a measure of one's motivation and interest. Verbal risk could also be viewed as a measure of one's motivation and interest, i.e., the willingness to speak out in class and question could be viewed as one of those attributes which McCaulley says distinguish non-majors from majors in science.

These below-average scores are probably measures of general low scores on these orientations (persistence, verbal risk, and manipulative), as suggested by the non-subject matter nature of the LSP instrument and the fact that the LSP instrument was administered, in this study, during the first class period of the biology course. Of course it is possible that students' previous experience with biology somehow influenced their responses on these orientations and are, in fact, a reflection of their persistence, verbal risk, and manipulative orientations to the subject matter of biology. Whether general orientations or specific biology orientations (persistence, verbal risk, or manipulative) are low, offering instruction in more preferred learning modes (such as visual instruction) for these students could positively affect their motivation. Interest might be piqued by providing practical knowledge in small group or discussion format, as suggested by Jensen (1987, Table 3, p. 35) and Campbell (1986, Table 8, p. 41).

Since students show above-average preferences for three of four study times, the BLC should continue to be open from morning to night. Grouping (small vs large) shows a preference for small groups. In the NMBC, no opportunities exist for small group interactions. Even in the BLC, students work mostly alone.

Table 29, p. 105 presents interesting data regarding spatial ability. According to this table, spatial ability is higher in successful students in the NMBC. These data may be problematic, because some of the spatial items (37 and 40, Appendix N) loading with the analytic items on the nine factor factor analysis (Tables 33 and 34, p. 117). Also, the reliability of the five item spatial subscale is low (.39, Table 10, p. 62). However, spatial ability was a significant predictor of success when the logistic regression was performed (Table 39, p. 129).

A spatial ability component is "visualization" (Keefe & Monk, 1988, p. 21) or the ability of a person to mentally rotate objects in space. Keefe & Monk (1988, p. 21) say that "The subject is presented with two-dimensional patterns that must be visualized in the imagination as three-dimensional shapes." Much of the content of the NMBC relies on students' ability to perform this "visualization" task. So, it is not surprising that spatial ability would be a significant predictor of success (Table 39, p. 129) or would be a subscale on the LSP that makes a difference in student performance (Table 29, p. 105).

Jensen (1986, Table 3, p. 35) lists the learning style preference of sensing (S) learners as moving from the concrete to the abstract in a step-by-step progression. Spatial ability, or the visualization component of it, seems to require something beyond the concrete experience, and may actually require abstract thinking. It is for this reason that attention to the spatial requirements of the NMBC is implicated by the results of this study.

RECOMMENDATIONS FROM THE LSP FOR COURSE DESIGN

1. Capitalize on students' above average spatial, categorization and sequential processing skills by providing more learning opportunities which require those skills. In the case of spatial ability for students who are sensing (S), provide more concrete examples of theories that require the ability to visualize concepts in space. An example might be in the content of chemical reactions, of photosynthesis and respiration. Many teaching aids which concretize these two abstract concepts are available for purchase from various companies.

2. Provide more visual instruction as a required part of the course. At the present time, videotapes are presented only in recitation. Students receive no formal penalty for not attending recitation. Instead of presenting videotapes only in recitation (which is poorly attended), consider requiring participation in visual opportunities for learning in dynamic formats such as interactive videodisk (Oliver, 1985).

3. Reduce total reliance on audio tape for instruction.

4. Consider lengthening the evening hours for the BLC and testing center, since students show a strong preference for study time in the evening.

5. Provide and require structured small group work with opportunities for discussion. The small group work and discussions should be supervised and led by teaching assistants.

IMPLICATIONS FOR RESEARCH REGARDING COGNITIVE DEMAND REQUIREMENTS

1. Since the data on the entire population (N=922) are available, further research should include a larger sample (larger than 96 students) and involve the analysis of more than six questions.

2. Raters of questions should be trained in evaluation of cognitive demands of instruction and of evaluation measures. They should also be familiar with the kinds of cognitive processes which students use when answering questions. Interrater reliability should be high.

3. Questions should be carefully examined for concept density. Concept density as a problem may be indicated by questions which require many cognitive processes within the same question. This problem was identified because no question of the 58 initially examined contained only one cognitive process (as measured by the LSP cognitive skill subscales of analytic, spatial, discrimination, categorization, sequential processing and memory). Every question required two or more processes, according to the three raters.

4. Reconstruct the LSP analytic scale to include item numbers 37 and 40. Omit item 26 from the analytic subscale.

CONCLUSIONS REGARDING THE CURRY LEARNING STYLE FRAMEWORK

One of the purposes of the study was to gather data to support a part of Curry's (1983) proposed learning style framework, as presented in Figure 1 (p. 16). Pearson correlations among the eight MBTI dimensions and the 23 LSP subscales showed low relationships, but some were highly significant (Table 33, page 117). Curry (1983) says that if the theory is true, then the MBTI dimensions (personality) should be able to predict the other layers of the onion [instructional preference and information processing, and Claxton & Murrell's (1987) addition, social interaction, Figure 1, p. 16], measured in the study by subscales of the LSP.

The canonical correlation supports Curry's theory for several subscales of the LSP. Verbal risk is responsible for most of the relationship between the LSP and the MBTI. Verbal risk is also the subscale which shows the most frequent significant correlations with dimensions of the MBTI. Verbal risk correlates positively with extraversion (E).

Verbal risk correlates negatively with introversion (I), sensing (S), and feeling (F). The predictable dimension of the MBTI is extroversion (E) because E and verbal risk are positively correlated and seem to measure a similar construct - willingness to speak out. The relationship of verbal risk to intuition (N) is harder to interpret, and is thus less useful as a predictor. More research would need to be done to explore the relationship of extroversion to intuition.

Other LSP subscales which support Curry's theory are observable in the contribution to the relationship between the LSP and MBTI represented in the second canonical correlation. These variables are persistence, memory, manipulation, and evening study time. All of these five LSP subscales can be predicted, as hypothesized by Curry, from the MBTI.

IMPLICATION FOR COURSE DESIGN

Presumably, if a class were filled predominately with extroverts (E), a high score in the LSP subscale, verbal risk, would be predictable. However, this was not the case for the group verbal risk subscale score for the non-majors in biology. Table 19 (p. 86) shows that 61.4% of non-majors in biology are extroverts (E), but verbal risk subscale score on the LSP (Table 17, p. 83) is below average at 48.75. Probably, the difference lies in Table 16 (p. 83), where we observe a drop in verbal risk score when scores of twelfth grade students are compared to those of college students. More than likely, extroverts (Es) are probably choosing not to speak out in class because 54.2% of non-majors in the NMBC are freshmen (Table 12, p. 78), in new and unfamiliar territory. It could be that for individuals, rather than for groups, predictability of learning preferences could be inferred and used by teachers. Many subscales, other than verbal risk, on the LSP are related to dimensions of the MBTI (Tables 34, p. 117 and 2, p. 18) and could possibly be predicted by MBTI scores. For example, discrimination skill has a low correlation, without significance, with sensing (S). Yet in knowing the detail orientation of sensing (S) individuals, as listed by Lawrence in Table 4, (p. 37), discrimination could be predicted from knowing if a person's perception preference was sensing (S). Other examples are with the persistence MBTI orientation: persistence correlates positively with judging (J) and negatively with perceiving (P). Jensen (1986, Table 3, p.35) and Lawrence (1984, Table 4, p. 37) describe drive to closure and completion of tasks of persons with judging (J) orientation.

The opposite, or negative, correlation can be observed with perceiving (P) individuals. According to Jensen (1986, Table 3, p. 35), Ps care less about deadlines and completion of tasks. Feeling (F) correlates negatively significantly, though low, with persistence. According to Jensen (1986, Table 3, p. 35), Fs are most motivated when given personal encouragement, a factor not provided for in the NMBC. Kern and Matta (1988) found that intuitive feeling (NF) individuals need help in sequencing and pacing of instruction. Bozeman's findings (in Sharma, 1987) were that extroverted - perceiving (E__P) individuals overwhelmingly tend to drop out of computer tasks. The only two MBTI groups who fail at a higher rate are ESFP and ENTP, the same as Bozeman's findings in the E__P dimension. Therefore intervention should be made with individuals of these types, specially the male ESFP non-majors, since they are more numerous than the male science major (Table 25, p. 98).

Other examples of MBTI/LSP correlates which could be useful for investigation in predicting outer layers of Curry's (1983) "onion" are: positive correlates of thinking (T) with LSP subscale of manipulative, negative correlate of judging (J) with LSP subscale of mobility and positive correlate of perceiving (P) with mobility.

RECOMMENDATIONS FOR RESEARCH

1. If the LSP is going to prove useful as a predictor instrument in higher education, some of the subscales need to be revised. The analytic scale, for example, may need to be revised to include items 37 and 40, items which are presently classified as spatial items. Item 26 should be removed from the analytic scale.

2. Because of some evidence in the six item analytic scale ANOVA (Tables 35 and 36, p. 118), which shows a three factor interaction between question type, amount of analytic skill and right vs wrong answers, give longer tests which measure individual LSP subscales, specifically analytic subscale. The LSP Technical Manual lists two longer tests which measure analytic skill (Keefe & Monk, 1988, p. 17).

3. Continue the cognitive process question analysis begun on 96 students and six questions. This should be done following administration of the longer test for analytic skill and following training of question raters. Question raters should be instructed in cognitive demand requirements of test questions.

4. Reexamine correlations between the longer subscales and dimensions of the MBTI. For example, LSP analytic skill subscale and MBTI dimension thinking (T) may correlate if a more reliable analytic subscale is used.

5. Spatial ability should be further investigated as a required skill for success in biology. Longer tests with higher reliability which measure spatial ability should be administered to non-majors in biology.

6. Remediation of spatial skills should occur if it is determined to be a reliable predictor of success in biology.

APPENDIX A

BIOLOGY 110 (BIO-CMI) SYLLABUS

BIOLOGY 110 (BIO-CMI) SYLLABUS, WINTER QUARTER 1988
Dr. Russell V. Skavaril, Coordinator, RH 60B, 2-9861
Ms. Mary M. Finnen, Associate Coordinator, RH 60E, 2-9761
Mr. Steven M. Lawton, Assistant Coordinator, RH 60F, 2-9761

STUDENTS: The information on this syllabus has been provided to help you keep track of some important dates and assignments. If you encounter any problem, you are encouraged to contact your instructor. Messages may be left in RH 60, 2-9761. The content presentation listed below will be set up in the Bio-Learning Center (BLC) on the dates stated. The following week's experiments will also be available in Module 1 the Monday (at noon) prior to the scheduled week. You are responsible for the material outlined by the objectives for each unit of study. Objectives and vocabulary list for each unit are available as a handout in the Bio-Learning Center.

DATE	UNIT LETTER	SUBJECT AREA	READING ASSIGNMENT IN TEXTBOOK (DAVIS & SOLOMON)
Jan. 5 - Jan. 9	A	Microscopy & Levels of Organization	3-25, 60-66, 200-209, 261-270
Jan. 7/8		Learning Style Profile	
Jan. 11-16	B	Cellular Organization and Function	pp. 4-13, 60-84, 86-101, 155-164
Jan. 14/15		TV Presentation in Recitation:	Architecture of Cells (Chan. 5)
Jan. 18	HOLIDAY - No Recitation; BLC, TC, and OFFICES CLOSED		
Jan. 19-23	C	Composition of Living Matter	pp. 26-59, 200-213, 237-243
Jan. 19/20		TV Presentation in Recitation:	Cell Division & The Life Cycle (Part 1) (Channel 5)
Jan. 21/22		TV Presentation in Recitation:	Chemistry of Life (Channel 5)
Jan. 25-30	D	Chemical Processes of Life I (DNA, RNA & Protein Synthesis)	pp. 53-58, 72, 74-75, 105-121, 214-235
Jan. 26/27		TV Presentation in Recitation:	DNA (Channel 5)
Feb. 1-6	E	Chemical Processes of Life II (Photosynthesis)	pp. 76, 119, 122-136, 353-366
Feb. 2/3		TV Presentation in Recitation:	The Green Cycle (Channel 5)
Feb. 8-13	F	Chemical Processes of Life III (Respiration)	pp. 137-152
Feb. 9/10		TV Presentation in Recitation:	Metabolism (Channel 5)
Feb. 15-20	G	Genetics	pp. 686-688, 156-198
Feb. 16/17		TV Presentation in Recitation:	Cell Division & The Life Cycle (part 2) (Channel 5)
Feb. 22-27	H	Reproduction & Development, Plant & Animal	pp. 61-62, 169-171, 633-659, 664-681, 351-408
Feb. 23/24		TV Presentation in Recitation:	Reproduction (Channel 5)
Feb. 25/26		TV Presentations in Recitation:	Life in the Womb and Chemistry of Life: Hormones & Endocrine System (Channel 5)
Feb. 29 - March 5	I	Evolution & Adaptation	pp. 4-25, 685-723
Mar. 1/2		TV Presentation in Recitation:	Natural Selection (Channel 5)
Mar. 7-11	J	Ecology	pp. 754-821
Mar. 8/9		TV Presentation in Recitation:	Cities of Nature: The Ecosystem (Channel 5)

March 11 LAST DAY OF REGULARLY SCHEDULED CLASSES. BLC closes for last time FRIDAY, MARCH 11 at 4:30 p.m.

March 11 ALL TESTING ON INDIVIDUAL UNITS MUST BE COMPLETED BY 4:30 p.m. TODAY.

March 12-16 SATURDAY-WEDNESDAY OF FINALS WEEK. TESTING RESTRICTED TO TAKING AND/OR RETAKING THE FINAL EXAM (UNIT P).

March 16 ALL TESTING MUST BE COMPLETED BY 4:30 PM TODAY.

BOOKS USED IN COURSE:
(REQUIRED) The World of Biology, third edition. Davis & Solomon
(REQUIRED) General Biology Laboratory Manual, Eberhard.

BLC = BioLearning Center (RH Modules)
TC = Testing Center (RH 52)

JANUARY 1988

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	4 Winter Quarter Begins	5 9 a.m. BLC opens UNIT A	6	7 Learning Style <-----Profile ----->	8	9 BLC open TC closed
10 BLC & TC closed	11 Unit B	12 TC Orientation <-----To Testing----->	13	14 <---Architecture of Cells Film---->	15	16 BLC & TC open
17 BLC closed TC open	18 HOLIDAY	19 <---Cell Division and the Life Cycle film---> (Part 1) UNIT C	20	21 <----Chemistry of Life film------>	22 last day to drop w/o W	23 BLC & TC open
24 BLC closed TC open	25 Unit D	26 <------DNA film------>	27	28	29	30 BLC & TC open

FEBRUARY 1988

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
31 BLC closed TC open	1 Unit E	2 <----The Green Cycle film------->	3	4	5	6 BLC & TC open
7 BLC closed TC open	8 Unit F	9 <---Metabolism film--->	10	11	12	13 BLC & TC open
14 BLC closed TC open	15 Unit G	16 <---Cell Division & the Life Cycle film—> (part 2)	17	18	19 last day to drop w/o a petition	20 BLC & TC open
21 BLC closed TC open	22 Unit H	23 <—Reproduction film—>	24	25 <—Life in the Womb; Hormones & Endocrine Systems films—>	26	27 BLC & TC open

MARCH 1988

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
28 BLC closed TC open	29 UNIT I	1 <----Natural Selection film----->	2	3	4	5 BLC & TC open
6 BLC closed TC open	7 UNIT J	8 <---Cities of Nature: The Ecosystem film--->	9	10 NOON: Grad.Sr. deadline	11 Last day for BLC & Unit Testing; 4:30pm BLC closes/qtr	12 TC open for final only
13 TC open for final only	14 TC open for final only	15 TC open for final only	16 TC open for final only	17 GRADES TURNED IN	18 Winter Commencement 9:30 a.m.	19

APPENDIX B

BIOLOGY FACILITIES, POLICIES AND PROCEDURES

BIOLOGY 110/110N, GENERAL BIOLOGY

FACILITIES, POLICIES, AND PROCEDURES

WINTER QUARTER 1988

Dr. Russell V. Skavaril, Coordinator, RH 60B, 2-9861
Ms. Mary M. Finnen, Associate Coordinator, RH 60E, 2-9761
Mr. Steven M. Lawton, Assistant Coordinator, RH 60F, 2-9761

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INTRODUCTION

General Biology utilizes the audio-tutorial method of individualized, self-paced instruction, a method which recognizes that each student is an individual with a unique background, strengths, weaknesses, and goals. The complete course is based on written behavioral objectives, reading assignments, and vocabulary lists. The course is an integration of lectures, recitations, t. v. presentations, slide presentations, laboratory exercises, laboratory demonstration experiences, and readings.

The lectures are on tape and are presented, with integration of laboratory exercises and demonstrations, in the first three modules of the Bio-Learning Center (BLC), which is located in the basement of Rightmire Hall. The BLC is available to students approximately 64 hours per week, and students are free to spend as much time in the BLC as is needed. In general, an average student should expect to spend approximately three to four hours per week working in the BLC. General Biology consists of ten units of instruction (Units A, B, C, D, E, F, G, H, I, and J) as detailed on the course syllabus.

A student in General Biology receives a course grade based upon the student's performance on the ten unit tests (there is a unit test for each of the units of instruction mentioned above) and on a comprehensive final examination (unit test P). The tests are administered by means of a computer in the General Biology Testing Center, Room 52, Rightmire Hall, which is open 70 hours per week during the quarter. A student is allowed to repeat each test up to a limit of four attempts on each unit test and up to three attempts on the final examination, with the best scores then being used to determine the student's grade in the course.

A student is responsible for doing at least one unit of work per week, which includes taking a test on that unit. However, students are free to move through the course material at a faster rate.

STUDENT RESPONSIBILITIES

It is the expectation of the instructional staff in General Biology that each student be aware of, understand, and observe the following, which are the responsibilities of a student in this course.

1. Be familiar with the content of this handout and all other handouts distributed to students enrolled in the course.

2. Attend the two weekly meetings of the recitation section for which the student has registered and, at each such recitation section meeting, sign the attendance sheet. Participate in the recitation discussions.

3. Complete all assignments given on the syllabus by the dates specified.

4. Take at least one test on Units A and B by the end of the second week of the quarter. Thereafter, take at least one test on the current unit(s) of study for each week. All tests on the individual units must be completed on Friday, March 11, 1988.

5. Take the comprehensive final examination no later than Wednesday, March 16, 1988 before 4:30 p.m., at which time the General Biology Testing Center will close for the quarter.

6. Complete a course evaluation form at the end of the quarter, i. e. after the final examination has been taken.

7. Immediately contact the recitation instructor (a message may be left at Room 60 Rightmire Hall, 292-9761) when any problem arises which will prevent you from meeting your responsibilities in General Biology.

8. Students who are graduating must have all of their work in Biology 110/110N completed by noon on Thursday, March 10, 1988.

HOW TO USE THE BIO-LEARNING CENTER

When you are ready to begin work in the Bio-Learning Center, simply go to the Biology 110/110N tag board on the wall of the north hall of the basement of Rightmire Hall. Follow these directions.

1. Select a tag from the board, a tag corresponding to the unit on which you wish to work.

2. Obtain a copy of the handout giving the reading assignments, the learning objectives, and the vocabulary list for the unit on which you wish to work. This handout is available from the instructor on duty in the Bio-Learning Center. In addition to that handout, you must also have with you your text book (Davis and Solomon) and your laboratory manual (Eberhard).

3. Go to the carrel in the module specified on the tag.

4. Place the tag on the hook outside the carrel.

5. Sign your last name on the sign-in sheet inside the carrel.

6. Get comfortable. Read the objectives for the unit on which you wish to work and look through the reading assignment pages of the text book and the laboratory manual.

7. Put on the earphones, and press the white tape-control button labeled "Review."

8. Listen to the recorded material and instructions on the tape and follow the directions given.

9. When you are ready to leave, ask the instructor on duty to sign you out from the carrel.

10. Return the tag to the tagboard.

These are the open hours for the Bio-Learning Center:

Monday - Thursday -- 8:30 a.m. - 9:30 p.m.
Friday -- 8:30 a.m. - 4:30 p.m.
Saturday -- 8:30 a.m. - 12:30 p.m.
Sunday -- CLOSED

For Winter Quarter 1988, the Bio-Learning Center will open at 9:00 a.m., Tuesday, January 5, 1988. The Bio-Learning Center will close at 4:30 p.m., Friday, March 11, 1988.

The instructional tapes will be available whenever the Bio-Learning Center is open; however, the laboratory demonstrations and materials needed to perform the laboratory exercises will be available only for three weeks at a time. There are alternative ways (see below) to listen to the tapes, but the Bio-Learning Center is the only place where the laboratory demonstrations and exercises are available.

You are free to repeat material in the Bio-Learning Center as often as you feel is necessary. You may also repeat the experiments. Many students find it effective to work with a friend on the experiments, and this is perfectly acceptable. Since your grade is not affected by how well other students do, you should feel free to share information with fellow students. However, use your own laboratory book. It is counterproductive to use another student's book since the answers in it may very well be incorrect.

Do take advantage of the presence of the instructor(s) in the Bio-Learning Center. They are there to help you.

It is an effective strategy to have completed at least half of each week's instructional unit before the first meeting of your recitation section that week and to have completed the entire unit by the second recitation section meeting of the week. In following that strategy, however, you will probably want to avoid attempting to use the Bio-Learning Center during peak hours, which are commonly mid-mornings and mid-afternoons.

It is an excellent practice to review previous material on a regular basis.

When you have completed your work in the Bio-Learning Center for a particular unit, study the required text assignments in Davis and Solomon and in Eberhard, answer all of the questions asked found in those reading assignments, and study your notes concerning the relevant television presentations. Then, you should be ready to take a test on that unit.

RECITATION SECTIONS

Each week, you will attend two 48-minute recitation sections. These meetings are discussion sections; they are not lectures. You should come to these meetings prepared to participate by asking your instructor questions. You should pay attention to the questions which other students ask and to the answers which your instructor gives. Very commonly, an instructor will answer a particular question by pointing out where the relevant material to answer a question may be found in the texts and by providing a brief summary of the material. Accordingly, you should bring your texts to recitation. In the absence of questions from the students, the instructor will ask questions.

Several television presentations will be given and discussed in recitation. Students will be held responsible for the content of such presentations.

The recitation sections are also important in that it is there where the instructor will announce various course details, modifications, approaching deadlines, administrative details, etc.

THE GENERAL BIOLOGY TESTING CENTER

The General Biology Testing Center is located in Room 52 Rightmire Hall. In this room are over thirty computer terminals on which students will take tests for this course. An orientation to the General Biology Testing Center will be given in recitation. These are the Winter Quarter hours for the center:

Monday - Thursday -- 8:30 a.m. - 9:30 p.m.
Friday -- 8:30 a.m. - 4:30 p.m.
Saturday -- 8:30 a.m. - 12:30 p.m.
Sunday -- 1:30 p.m. - 7:30 p.m.

The General Biology Testing Center will open this quarter as follows for the students indicated:

January 12, 1988 -for students in Biology 110 in Tuesday/-Thursday recitation sections and all students in Biology 110N

January 13, 1988 -for students in Biology 110 in Wednesday/-Friday recitation sections

Your behavior in the General Biology Testing Center must be the same as for any testing situation. University Rules require that an instructor report all instances of what the instructor perceives as academic misconduct to the University Committee on Academic Misconduct. Each student in General Biology will have an individual sign-on code. Under no circumstances whatsoever should one student sign on the computer or attempt to take a test with another student's sign-on code.

When you take a test at one of the computer terminals in the General Biology Testing Center, your behavior must be beyond reproach in order for you to avoid becoming involved with charges and the serious consequences of academic misconduct. Even the presence of crib notes on or near your person will be interpreted as an attempt to cheat. Accordingly, we absolutely require that all books, notes, study sheets, walkman radios or cassettes, other personal belongings, etc. be left either on the bookshelf near the door or on the floor under the table on which the computer terminal sits. Talking to another student is not permitted, nor are you allowed to look at the screen on a terminal being used by another student. Test questions are not to be copied from the terminal.

Scratch paper is available from the monitors on duty, and such scatch paper must be turned in to the monitor when you leave the terminal. The only written information which a student is permitted to carry away from the terminal is a listing of the numbers of the objectives not mastered on a test and study guide page numbers. These numbers will allow the student to identify the objectives not mastered and material which should be studied.

Certain questions will refer the student to material in what we call the visuals book, a binder located next to each terminal. Students are allowed to use a visuals book only during a test. A visuals book may not be borrowed for study.

Certain tests will include one or two questions from previous units. Therefore, you should review the prerequisite units involved and take the tests in the correct order (A ... P).

If, during a test, you encounter problems or have a question, simply raise your hand to call the monitor on duty to you. The monitor will listen to your question and answer it if regulations allow; otherwise, the monitor will inform you that regulations do not permit the monitor to answer the question. The monitor will gladly assist you with any mechanical difficulties you may be experiencing with the operation of the terminal. In general, a monitor will attempt to interpret a question which the student has found ambiguous; however, the monitor will not discuss or clarify course material related to a given question. Nor will the monitor provide the correct answer for a question which the computer has scored as incorrect. In addition, the monitor will not tell you whether or not your answer to a question has been spelled correctly, correct spelling being the responsibility of the student.

HOW TO TAKE A TEST IN THE GENERAL BIOLOGY TESTING CENTER

During the second week of the quarter, in the recitation section meeting, the recitation instructor will present a comprehensive orientation to the use of the General Biology Testing Center and how the testing program operates. At that time, each student will receive an individual sign-on code. To take a test, follow these steps.

1. Go to Room 52 Rightmire Hall and show the monitor on duty at the desk immediately inside the door your photo identification. Under no circumstances will a student be allowed to take a test without a photo identification.

2. Sign your name on the appropriate blue sheet. One blue sheet is for students coming to take a test on a "walk-in" or "first-come, first-served" basis and serves as a record of those students waiting to be assigned to a terminal. A student is not allowed to be on the same waiting list at more than one position on the list. The second blue sheet is for students who have reservations. The reservation procedure is detailed below.

3. When a terminal becomes available and it is your turn, the monitor will assign you to a terminal. At this time, the monitor will fill in all of the remaining information on the blue sheet by your signature except the sign out time, which the monitor will record when you leave the General Biology Testing Center.

4. You will be given 30 minutes at your assigned terminal to take your test(s). You are allowed to take only one test on a given unit in any one session. Then, you must sign off and study for at least 30 minutes before you will be allowed to retest over the same unit. You are, however, allowed to test over several different units during the same session. If not all of the terminals are in use and no other students are waiting for a free terminal, then you will be allowed additional time beyond the 30 minutes. In general, you will find that 30 minutes is more than adequate for your completion of a test. If, however, you are not finished with a test when your time on the terminal is up, the monitor will sign you off such that, when you next sign on the computer, your test will resume with the next question. Accordingly, there is no reason why you should be rushed for time. If an emergency should arise during a test, summon the monitor to sign you off the computer and thereby conclude your session. Do not attempt to sign yourself off in the middle of an exam.

5. Be certain that all of your personal belongings are placed on the bookcase by the door or on the floor under the table of the terminal to which you have been assigned. You are permitted to have a piece of scratch paper at the terminal, and the monitor will provide you with that paper.

6. Follow the directions which were given you in recitation and sign on the computer. Make or cancel a reservation, if you wish, before you start the test.

7. Take the test. There are 25 questions on the unit tests, 50 questions on the comprehensive final examination. The questions are of the multiple choice or fill-in-the-blank type. Each test consists of a prescribed mixture of A-, B-, and C-level questions. An A-level question is straight recall and is worth 1.0 point. A B-level question is an application question and is worth 1.5 points. A C-level question is of the practical exam type and is worth 2.0 points. Consult the visuals book next to the terminal if you are directed to do so when the computer presents you with a question. For each test, the questions are drawn from a very large bank of questions, so large, in fact, that it is virtually impossible for any two tests on the same unit to be identical. Clearly, retaking a test in the hope that the questions will be identical to those on a previous test will not be at all effective.

8. If the computer scores one of your answers as incorrect but you feel your answer was correct, raise your hand to summon the monitor before you transmit to get the next question. In order for you to receive credit for a question which the computer has scored as incorrect but which you feel is correct, you and the monitor must fill out a green "problem sheet." The monitor, who will be familiar with the procedure involved, will assist you in filling out the problem sheet and will see to it that the problem sheet is processed.

9. At the end of each test, the computer will inform you of the numbers of the objectives on which you missed questions. Jot down those numbers and restudy the corresponding material before you retest on that unit. The monitor will gladly discuss the objectives with you after you have completed your testing session.

10. When you have completed your session at the terminal, sign off by selecting item six from the menu of choices. Summon the monitor if you experience any problems in attempting to sign off the computer. Inform the monitor that you have signed off, whereupon the monitor will record the time on the blue sheet.

TEST LOCKOUTS

In addition to the 30-minute session limit mentioned above, there is a system of additional lockouts from testing, a system which has been implemented in order to prevent student abuse of the retesting option and to assure that students realize that only additional study between tests will result in an improvement of a test score. There are three types of additional lockouts.

1. SESSION NON-MASTERY LOCKOUT. If you do not achieve a score of at least 70% on any two tests during the same session, then the computer will not allow you to do any further testing at all until the next day, at which time the computer will automatically remove the Session Non-Mastery Lockout.

2. UNIT NON-MASTERY LOCKOUT. If you do not achieve a score of at least 70% after two initial attempts on that unit test, then you will be locked out from further testing on that unit. This type of lockout will not be removed automatically; you must first have a conference with your recitation instructor. Only your instructor will be able to remove this lockout; however, before your recitation instructor will remove this lockout, you must be current with your testing. You will again be locked out for this unit test if you do not achieve a score of at least 70% on your third test of the unit. A unit non-mastery lockout on one unit will not, however, prevent you from testing on other units provided you are not locked out of them.

3. UNIT MAXIMUM TESTS LIMIT. You will be permanently locked out from a unit test after four attempts on that unit test, and you will be permanently locked out from further testing on the final examination after three attempts.

RESERVATION PROCEDURE FOR TERMINALS IN THE TESTING CENTER

A terminal reservation system is available in order to assure that students can have adequate use of the terminals in the General Biology Testing Center. Proper use of the reservation system will decrease the amount of time you spend waiting for a terminal to become available, particularly towards the end of the quarter when many students are trying to use the testing facilities.

You will be able to make two half-hour reservations per week for three weeks in advance of the current date. For purposes of this reservation system, the week begins on Monday and ends the following Sunday. You will be able to make your reservations from the terminals in the General Biology Testing

Center and from the terminals located in Browsing Room 7, Main Library. These same facilities may be used to cancel a reservation. If you have a reservation but are unable to keep it, please use the available facilities to cancel the reservation so that other students will have the time available to them.

The actual procedure to use the computer to make or to cancel a reservation is quite simple. The computer will actually lead you through the process; simply follow the directions given to you by the computer.

The last week of classes and the week of final examinations are weeks when the General Biology Testing Center is intensively used. Students will particularly want to have reservations during those two weeks, and reservations for those weeks can be made starting on Thursday, February 25, 1988.

If you do not arrive at the General Biology Testing Center and claim your reservation within five minutes after the time of your reservation, your reservation will be cancelled.

Very occasionally, due to mechanical failure or other circumstances beyond our control, the computer will not be working at the time of your reservation. We can only apologize for the inconvenience and hope that such computer failures happen only infrequently. Your understanding of such situations will be appreciated.

YOUR GRADE IN BIOLOGY 110

Your grade in the course is entirely based on your cumulative score achieved over the 10 units of the course, your score on the final examination, and your bonus points (see below). No consideration whatsoever will be given to borderline cases. The plus and minus system of grading is used in the course. When we calculate the course grade, we will use a zero for any unit test which has not been taken before 4:30 p.m., Friday, March 11, 1988. Similarly, we will use a score of zero for your final examination score if the final examination has not been completed by 4:30 p.m., Wednesday, March 16, 1988.

Throughout the quarter, you can see how well you are doing by checking your performance record and your cumulative score when you are signed on the computer.

The maximum total points available in this course is 406 points, and the table on the following page gives the scale which will be used to assign course grades.

COURSE GRADE	CUMULATIVE SCORE (per cent)	CUMULATIVE SCORE (points)
A	93 - 100	376.0 - 406.0
A-	90 - 92	363.5 - 375.5
B+	87 - 89	351.5 - 363.0
B	83 - 86	335.0 - 351.0
B-	80 - 82	323.0 - 334.5
C+	77 - 79	311.0 - 322.5
C	73 - 76	294.5 - 310.5
C-	70 - 72	282.5 - 294.0
D+	68 - 69	274.5 - 282.0
D	60 - 67	242.0 - 274.0
E	0 - 59	0.0 - 241.5

BONUS POINTS

There are three sources of bonus points for students in this course. The first source is from handing in completed laboratory work as such work is called for in the meetings of the recitation sections.

Bonus Points Completed Laboratory Work

At the start of each recitation section meeting, starting with the week of January 11 and continuing through the eighth week of the quarter, the instructor will collect from each student a random page of laboratory work from the laboratory manual (Eberhard) --a random week's unit of study. The specific page will vary from one recitation section to another. The page will be accepted by the instructor only at the start of the recitation section meeting. If the page is not handed in at that time, the student will receive no bonus points for the work involved.

The instructor will then examine the collected pages and give one bonus point to the student concerned if the student has completed the laboratory work on the collected page. The pages will then be returned to the students at the following meeting of the recitation section. Up to 14 bonus points will be available by this method. The bonus points from the laboratory work will be registered on the computer during the ninth week of the quarter.

We are unable to define (nor do we have the time to verify) what is a valid absence from recitation. Accordingly, our policy must be that the bonus points will be given only if the selected laboratory page has been completed and only if the page is handed in when called for by the instructor. The policy is simple. If you are present at recitation and hand in the page of work called for, and if the work has been completed, then you get the bonus point; otherwise, you do not get the point.

Bonus Points For Prompt Unit Mastery

The second source of bonus points for students in this course is from the student achieving mastery on the various unit tests by the corresponding testing deadline. These bonus points are awarded to students who achieve a score of at least 70% on a unit test according to the following table:

BONUS POINTS AVAILABLE FOR PROMPT UNIT MASTERY

UNIT	DEADLINE (mm/dd/yy)	BONUS POINTS AWARDED IF FIRST MASTERY IS ACHIEVED BY 4:30 P.M. ON DEADLINE DATE ON TEST			
		#1	#2	#3	#4
A	01/29/88	2	1	0	0
B	01/29/88	2	1	0	0
C	01/29/88	2	1	0	0
D	01/29/88	2	1	0	0
E	02/05/88	2	1	0	0
F	02/12/88	2	1	0	0
G	02/19/88	2	1	0	0
H	02/26/88	2	1	0	0
I	03/04/88	2	1	0	0
J	03/11/88	2	1	0	0

Bonus Points For LEARNING STYLE EVALUATIONS

The instructional staff in General Biology is interested in the learning characteristics of students in Biology 110/110N in order to improve course instruction. Therefore, the Learning Style Profile will be administered in the second class period.

Learning Style is a measure of how a student learns and likes to learn. Style includes cognitive, affective and environmental elements that describe how learners perceive, interact with and respond to the learning environment. A knowledge of learning style offers teachers and students a more rational, more personalized, more modern approach to education.

The Learning Style Profile will only be administered once during the quarter, but you will be awarded three bonus points for completing the inventory. During the same class period, you will be given another learning style evaluation, Myers-Briggs Type Inventory (MBTI) to take home, complete, and return the next class period. You will be awarded three additional bonus points for completing and returning the MBTI.

Later in the quarter the results of the inventory will be given to you in recitation. The explanation of your results will be given in a general assembly on February 16 and 17, the times of which will be announced in recitation. If you attend a general assembly you will receive an additional 3 bonus points for a total of 9 possible bonus points.

This bonus point system will enable the student to receive up to 14 bonus points from handing in completed laboratory work, up to 20 bonus points from prompt unit testing, and up to 9 bonus points for the learning style evaluations--a maximum of 43 bonus points. The bonus points will be added to the cumulative points obtained by the student from testing. The total number of points possible from testing alone is 406. The bonus point system will allow the maximum total to be as high as 449 or 111% for the course.

IMPROVING YOUR GRADE

After you have taken at least one test on each of the required units and the final examination, you are in a position to improve your course grade. Begin by comparing your cumulative score plus your bonus points with the grading scale. To improve your cumulative score, you must increase the cumulative number of points you have obtained. The total number of points possible from testing is 406. There are 43 possible bonus points.

You must be aware of the rounding done by the computer when the computer displays your cumulative percentage score. The computer does keep track of the figures to the right of the decimal point in your cumulative score percentage; however, the computer does not display those figures. For example, an actual percentage score of 83.499999 would be displayed as 83, while an actual score of 83.500000 will be displayed as 84. Your total points, of course, will not be affected by rounding.

In order for you to understand how to improve your grade, consider this example. Suppose a student completes the course with 310 points from testing out of 406 points, a cumulative score from testing alone of 76%. The grade would be a C. To get a B-, this student's cumulative score must be at least 80%, an increase of 4% for the cumulative percentage score, or approximately 13 more points. The student also has 10 bonus points coming. The student still needs an additional 3 points in order to get the B-. The student examines the performance record (option 2 from the menu of choices) and notices that more than 15 points were lost on two units. The student studies the material on those units and retests. The student's total points from testing go up to 314; and, with the 10 bonus points considered, the student has a total of 324 points, a cumulative score of 80%. The student has the desired B-.

You can do the same thing to improve your grade, but you must restudy the material before you retest. You must also attend the meetings of your recitation section and turn in the appropriate laboratory page in order to get your bonus points. Otherwise, there is no way to improve your grade. You must put forth the effort and study.

The policy concerning giving an Incomplete grade to a student is very firm and simple. A student who has been attending recitation regularly, who has completed at least the first six units, who is passing the work completed, but who, due to extenuating circumstances beyond the control of the student finds it impossible to complete the course, will be considered for an Incomplete.

The decision to give a student an Incomplete will be made only by the coordinator of the course.

If circumstances arise such that you are unable to meet your course responsibilities and obligations, contact your recitation instructor immediately.

A student will sometimes behave irresponsibly during the quarter by cutting recitation class and falling behind with the assigned work. Such a student commonly does poorly on tests but fails to seek help. Then, when a legitimate problem (illness, death in the family, etc.) arises near the end of the quarter, the student seeks an Incomplete in the course. Usually, in such a case, an Incomplete is not granted due to the previous irresponsible behavior of the student. No one can predict the future, and emergency situations do arise. Accordingly, it is in the best interest of the student to behave responsibly against the possibility that such an emergency occurs and an Incomplete might be necessary.

If an Incomplete is given to a student, then that student will have until noon on the Friday of the sixth week of the quarter following the one in which the Incomplete was received to finish the course. For such a student, the original sign-on code will remain valid. The student's previous test scores will be retained, and the student will be allowed to continue testing when the Testing Center opens the next quarter. A student who is working on finishing an Incomplete has the responsibility, however, to contact the course coordinator and to complete the remaining course work by the deadline mentioned.

REVIEW OPPORTUNITIES

Review Carrels in the Bio-Learning Center

Each week, in the BLC, the tapes, slides, and some of the laboratory demonstrations and exercises for the previous week's work will be in designated carrels. In addition, certain other carrels will be set up so that you can request the lecture tape (but not the slides and laboratory materials) for the work of any week of the quarter. These review carrels will be identified on the tagboard, and you are welcome to use these review facilities.

You may listen to the current week's lecture tape or the previous week's lecture tape away from the BLC at a variety of locations. At these locations, dial 111 for the current week's tape; dial 132 for the previous week's tape. The tapes are started on the hour; i.e., 8:00, 9:00, 10:00, etc. You will not have control over the tapes; they will be played straight through. If you begin, for example, at 8:15 a.m., you will have missed the first 15 minutes of the tape. Questions about the availability of these facilities can be asked by your calling 292-9682. Here are the locations and hours for the remote area booths:

Lincoln Tower -- Room 1504
Main Library -- Room 105
Morrill Tower -- Room 310
Morrison Tower -- First Floor Study
Ohio Union -- Browsing Room
Royer Commons -- Basement, S-1
Siebert Hall -- Room 12
Stradley Hall -- Room B-3
Sullivant Hall -- Rooms 182 and 274

The hours, which are subject to change, for these facilities are: Monday through Thursday, 8:00 a.m. - 10:00 p.m.; Friday, 8:00 a.m. - 5:00 p.m.; Saturday, closed; Sunday, 2:00 p.m. - 10:00 p.m. Dialing system hours are subject to the building hours.

Tape Libraries

If you wish to have control over a review tape, use the facilities of the Tape Libraries, where the tapes may be heard but may not be removed from the facility. The Tape Libraries available, with hours subject to change, are:

Room 60, Denney Hall, 292-2793 or 292-9682
Monday through Thursday -- 9:00 a.m. - 9:00 p.m.
Friday -- 9:00 a.m. - 5:00 p.m.
Saturday -- closed
Sunday -- 2:00 p.m. - 9:00 p.m.
(TV video cassette tapes may be checked out and used in Room 60, Denney Hall.)

Room 108, Cunz Hall, 292-9776
Monday through Thursday -- 8:00 a.m. - 7:00 p.m.
Friday -- 8:00 a.m. - 5:00 p.m.
Saturday and Sunday -- closed

Tape Libraries and Dial Access System Closed January 18..

Anywhere Line

You may call 292-4328 and request any lecture tape to be played to you over the telephone. Request Channel 111 for the current week's tape or Channel 132 for the previous week's tape. In addition, you can request the tape for any unit to be played.

Your Own Copies of the Tapes

If you wish to make your own copy of a tape, simply take two, good quality 60-minute cassette tapes (or reel-to-reel) to any of the Tape Libraries and receive a copy of the unit you wish to study. Blank cassette tapes can be purchased at the Office of Learning Resources Store, Room 3, Lord Hall.

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APPENDIX C

BIOLOGY 110, COURSE OBJECTIVES, UNITS A-E

UNIT A, MICROSCOPY AND LEVELS OF ORGANIZATION

Reading Assignments in Davis and Solomon: pages 3-25, 60-66, 200-209, 261-270. Reading Assignment in Eberhard: pages 13-18.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Define "biology" and discuss its applications to human life and society.

2. Define "scientific method" and list the general sequence whereby scientists build on observations in the formulation of laws.

3. Outline the ethical dimensions of science and give examples of ethical problems that may arise in the course of a scientific investigation.

4. - 6. Reserved (objectives to be added for a future quarter).

7. Give the characteristics of a virus, specifically, a bacteriophage; describe the structure of a virus and trace the steps that take place in the process of viral infection.

8. Define adaptation and describe its function in promoting perpetuation of a species.

9. List and briefly describe the characteristics of living systems.

10. Reserved.

11. Define the terms biosphere, ecosystem, community, population, organism, organ system, organs, tissues, cells, organelles, macromolecules, molecules, atoms, and subatomic particles as these are treated in Figure 1-12 of Davis and Solomon and as the terms relate to a continuous hierarchy of levels of organization.

12. List in sequence and briefly describe each of the levels of organization as these are defined relative to Figure 1-12 of Davis and Solomon.

13. Reserved.

14. Summarize the contributions of M. J. Schleiden, T. Schwann, R. Hooke, A. van Leeuwenhoek, and R. von Virchow to the cell theory. In addition, identify modern methods by which scientists study cells.

15. Outline the history of the scientific investigation of the nucleic acids, giving the major contributions of Miescher, Watson, and Crick.

16. Explain why the cell is considered the basic unit of life and state the cell theory. Describe the general characteristics of cells, for example, size, range, and shape.

17. Compare and contrast the features of the compound light microscope with those of the stereomicroscope.

18. Identify at least one advantage of each of the three types of microscopes studied, i. e. compound light microscope, stereomicroscope, and electron microscope.

19. Compare and contrast the features of the compound light microscope with those of the electron microscope.

20. Define the terms magnification, resolution or resolving power, depth of field, field of view, and working distance.

21. Operate the microscopes in the laboratory by preparing wet mounts, focusing on specimens, and adjusting for various lighting effects.

22. Identify low, medium and high power objectives and noting the effects of each on resolving power, magnification, depth of field, field of view, and working distance.

VOCABULARY

(In addition to the underlined terms given above.)

amoeba (ameba)
asexual reproduction
base
coarse adjustment knob
compound
conclusion
condenser lens
constant
control
diaphragm
ecosphere
electron
eyepiece
fine adjustment knob
focus adjustment knob
homeostasis
hypothesis
in-base illuminator
inference
image inversion
metabolism
neutron
nucleic acid
objective lens
ocular lens
protein
proton
reflected light
sexual reproduction
stage
theory
total magnification
transmitted light
variable

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BIOLOGY 110/110N

UNIT B, CELLULAR ORGANIZATION AND FUNCTION

Reading Assignments in Davis and Solomon: pages 4-13, 60-84, 96-101, and 155-164. Reading Assignment in Eberhard: pages 19-32.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Explain why the cell is considered the basic unit of life and state the cell theory. Describe the general characteristics of cells, for example, size, range, and shape. Identify modern methods by which scientists study cells. Define, explain, and give examples of eukaryotic and prokaryotic cells.

2. Contrast prokaryotic and eukaryotic cells; contrast plant and animal cells. Compare and contrast the cellular structure and function of eukaryotes and prokaryotes.

3. Construct, by drawing and labeling, and explain the currently accepted model of cell membrane structure, the fluid mosaic model.

4. Draw and label a diagram of a prokaryotic cell, a plant cell, and an animal cell. Describe and list the functions of the principal organelles.

5. Locate in the illustrations and electron micrographs of the text the following structures:

   plasma membrane
   cytoplasm
   cell wall
   nucleus
   nucleolus
   nuclear envelope
   endoplasmic reticulum
   Golgi complex
   mitochondria
   chloroplast
   grana
   stroma
   nucleic acids
   ribosomes
   centrioles
   lysosomes
   vacuoles

6. Give a simple statement or two to describe the function of each of the structures and organelles listed in the preceding objective. Distinguish between smooth and rough endoplasmic reticulum and describe the functional relationship between ribosomes and endoplasmic reticulum. Describe how the Golgi complex packages secretions and manufactures lysosomes. State the function of the mitochondria and explain why these organelles are called the power plants of the cell. Compare microtubules and microfilaments and describe the microtrabecular lattice. Describe the structure and function of the cell nucleus.

7. Prepare microscope slides of "typical" animal and plant cells and describe your observations made when you view such slides under the compound microscope.

8. Discuss the importance of the cell membrane to the cell, describing the various functions it performs. Describe the structure of the cell membrane. Describe the functions of membrane proteins.

9. Describe the plant cell wall and its function.

10. Define and explain the terms selective permeability, diffusion, osmosis, and active transport. Give examples of each phenomenon occurring in human systems.

11. Reserved.

12. Identify the factors which affect the rate of diffusing particles and generalize the application of these factors relative to the cell membrane. Contrast the physical with the physiological processes by which materials are transported across cell membranes. Solve simple problems involving osmosis. For example, predict whether cells will swell or shrink under various osmotic conditions.

13. Summarize the currently accepted hypothesis of how small hydrophilic molecules are transported through the cell membrane.

14. Compare and contrast the phenomena "exocytosis" and "endocytosis." Explain the difference between the two types of endocytosis, "phagocytosis" and "pinocytosis."

15. Describe the general structure of a chromosome and give the general function of a gene.

16. State the biological significance of mitosis in two or three simple sentences. Describe the events occurring in each stage of mitosis with emphasis on the behavior of chromosomes.

17. Identify "chromosomes," "chromatids," and "common centromere" by locating these in the illustrations in your text.

18. Identify the stages of mitosis as observed in the onion root tip. Identify the stages in the cell cycle and describe the main events of each.

19. Draw, define, and explain in sentences the stages of the cell cycle starting with interphase and continuing on through the stages of mitosis, i. e., prophase, metaphase, anaphase, and telophase.

VOCABULARY

(In addition to the underlined terms given above.)

bacteria
cyanobacteria
carbohydrate
cell plate
cellulose
central vacuole
chromatin
cleavage furrow
concentration gradient
cristae
cyclosis
cytokinesis
cytoplasmic streaming
desmosome
differentially permeable
duplication
equilibrium
fat
gap junction
genetic material
homeostasis
hydrophobic
intercellular space
karyokinesis
lignin
lipid bilayer
microbodies
middle lamella
mitotic spindle
molecular motion
net movement
nuclear pore
nucleoplasm
pectin
photosynthesis
plasmodesmata
plasmolysis
protein
protein synthesis
replication
respiration
spindle fiber
solute
solvent
starch grain
thylakoids
vacuole
vesicle
zymogen (granules)

BIOLOGY 110/110N
UNIT C, COMPOSITION OF LIVING MATTER

Reading Assignments in Davis and Solomon: pages 26-59, 200-213, and 237-243. Reading Assignment in Eberhard: pages 1-7.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Interpret simple chemical formulas, structural formulas, and simple chemical equations.
2. Diagram the basic structure of the atom in accordance with the conventions presented in Chapter 2 of Davis and Solomon, showing the positions of protons, neutrons, and electrons.
3. Identify the biologically significant elements in Table 2-1 of Davis and Solomon by their chemical symbols, and summarize the main functions of each in living organisms.
4. Sketch the electron configuration of the sodium atom, the chlorine atom, and the sodium chloride compound.
5. Compare and contrast an atom with an ion.
6. Calculate the mass number given the number of protons and neutrons contained in the atomic nucleus.
7. Reserved.
8. Calculate atomic number, given mass number and the number of neutrons.
9. Reserved.
10. Define the term electron orbital and relate orbitals to energy levels; relate the number of valence electrons to the chemical properties of the elements. Compare and contrast electron shell with electron cloud.
11. Distinguish between the types of chemical bonds that join atoms to form ionic and covalent compounds, and give the characteristics of each these types of chemical bonding.
12. Contrast oxidation and reduction and explain how these processes are linked.
13. Distinguish between inorganic and organic compounds and identify the biologically important inorganic compounds.
14. Discuss the properties of water molecules and their importance to living things.

15. Compare and contrast the macromolecules carbohydrates, lipids, proteins, and nucleic acids by stating their biological importance, relative size, and function and by identifying the subunits of the macromolecules.

16. Distinguish between dehydration synthesis and hydrolysis, giving examples of both chemical processes.

17. Name and draw the "functional groups" of carbohydrates, lipids, proteins, and nucleic acids.

18. - 19. Reserved.

20. Identify the carboxyl group, the amine group, and the peptide bond in a given dipeptide.

21. Compare and contrast the terms primary, secondary, tertiary and quaternary structure in proteins.

22. Perform and interpret the laboratory exercises involving the Benedict's test for carbohydrates, the iodine test for starch, the Sudan test for lipids, the biuret test for protein, and the amino acid chromatography experiment.

23. Describe or diagram the basic chemical structure of a nucleic acid strand and distinguish chemically between DNA and varieties of RNA. Compare and contrast the purine and pyrimidine bases and sugar groups that comprise the nucleotides of DNA and RNA.

24. - 25. Reserved.

26. Given the base sequence of one strand of DNA, predict that of a complementary strand of DNA. Compare and contrast the structures of DNA and RNA.

27. Summarize the ethical and other objections that have been raised against recombinant DNA studies and give potential practical and research applications.

28. Outline the history of the scientific investigation of the nucleic acids, giving the major contributions of Miescher, Watson, and Crick. Give the kinds of evidence that indicates that nucleotides occur in matched pairs in DNA molecules.

29. Explain what Watson and Crick meant by "complementary base pairing." What kind of molecule bonds with a given nucleotide?

30. State the importance of hydrogen bonds in macromolecules.

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UNIT C, COMPOSITION OF LIVING MATTER

VOCABULARY

(In addition to the terms underlined above.)

- adenine
- amino acid
- amino group
- antiparallel
- cellulose
- cytosine
- denature
- deoxyribonucleotide
- deoxyribose
- disaccharide
- double helix
- electron configuration
- electrostatic attraction
- element
- energy level
- fat
- fatty acid
- glucose
- glycerol
- glycogen
- glycosidic bond
- guanine
- hydroxyl group
- ion
- isomer
- isotope
- macromolecules
- molecule
- monomer
- monosaccharide
- nitrogen base
- orbitals
- peptide
- phosphate group
- polar molecules
- polymer
- polysaccharide
- ribonucleotide
- ribose
- saturated fatty acid
- semiconservative replication
- starch
- thymine
- unsaturated fatty acid
- uracil

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UNIT D, CHEMICAL PROCESSES OF LIFE, PART I

Reading Assignments in Davis and Solomon: pages 53-58, 72, 74-75, 105-121, and 214-235. Reading Assignment in Eberhard: pages 43-47, and 115-119.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Describe the functions and chemical structure of proteins.
2. Describe the chemical structure of nucleotides and nucleic acid and explain the importance of these compounds in living organisms. Differentiate between mRNA, tRNA, and rRNA chemically and structurally by stating their function in the cell.
3. Explain the biological significance of the number of different amino acids and the number of possible combinations of three nucleotides.
4. Describe the process of transcription. Summarize the sequence of events that occur in translation. Describe the function of transfer RNA. List the functions of the ribosome. Apply your knowledge of the Central Dogma to explain protein synthesis in eukaryotic cells.
5. Compare and contrast the primary, secondary, tertiary, and quaternary structures of proteins.
6. Define the terms code word, codon, anticodon, replication, transcription, and translation as these apply to protein synthesis.
7. Construct a paper protein model by applying your knowledge of protein synthesis.
8. Identify the following men with their contribution to biological sciences: J. D. Watson and F. H. C. Crick, M. H. F. Wilkins, F. Jacob and J. Monod.
9. Define the terms catalyst, enzyme, and activation energy.
10. Construct a graph showing a hypothetical chemical reaction in the absence and presence of an enzyme. Label and explain the various parts of your graph, i. e., energy of activation.
11. Contrast enzyme induction and repression in prokaryotes. Define active site and the following types of inhibition: feedback, competitive, non-competitive, and irreversible. Compare the action and effects of the various types of enzyme inhibitors (e.g., competitive and noncompetitive inhibitors).

12. Apply your knowledge of enzymes by summarizing your laboratory experiences with these biologically important molecules.

13. Explain the function of enzymes and describe how they work. Describe factors, such as pH and temperature, that influence enzymatic activity.

14. Draw a diagram illustrating an operon and describe how it functions.

15. Compare and contrast the structures of nucleotides and ATP.

16. Define the term energy and contrast potential and kinetic energy.

17. State the first and second laws of thermodynamics and discuss their applications to living organisms and to the ecosphere.

18. Distinguish between work, energy, and free energy.

19. Distinguish between endergonic and exergonic reactions and explain how they may be coupled so that the second law of thermodynamics is not violated.

20. Explain the biological significance of energy of hydrolysis in energy-carrier molecules.

VOCABULARY

(In addition to the terms underlined above.)

acid
adenine (A)
adenosine diphosphate (ADP)
adenosine monophosphate (AMP)
adenosine triphosphate (ATP)
allosteric site
amylase
anticodon
A-site
base
base pairing
calorie
catalase
coding (plus) strand
coenzyme
cofactor
cytosine (C)
dehydration synthesis
denature
deoxyribose
disulfide bond
deoxyribonucleic acid, (DNA)
DNA polymerase
entropy
enzyme-substrate complex

genetic code
guanine (G)
hydrolysis
induced-fit model
minus strand
nitrogen base
oncogenes
peptide
peptide bond
pH value
phosphate group
polypeptide
polyribosome
protein
P-site
regulator genes
ribose
RNA polymerase
structural genes
substrate
thermodynamics
thymine (T)
triplet
uracil (U)

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BIOLOGY 110/110N

UNIT E, CHEMICAL PROCESSES OF LIFE , PART II
PHOTOSYNTHESIS

Reading Assignments in Davis and Solomon: pages 76, 119, 122-136, 353-366. Reading Assignment in Eberhard: 53-66.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Distinguish between autotrophic and heterotrophic cells.
2. Write a summary reaction for photosynthesis, explaining the origin and fate of each substance involved.
3. Identify the structures in green plants that function in photosynthesis. Describe the internal structure of a chloroplast.
4. Apply the terms reflected, transmitted, and absorbed light to the photosynthetic process.
5. Discuss the advantages of the C_4 pathway.
6. Describe the biological significance of the visible light spectrum, wavelength, and energy as these pertain to photosynthesis.
7. Summarize the events of the light-dependent and light-independent reactions of photosynthesis, explaining the role of light in the activation of chlorophyll. Compare and contrast the light-dependent and light-independent reactions of photosynthesis and explain the role of water, oxygen, sugar, coenzymes, ATP, light energy, chlorophyll, and photophosphorylation in those reactions.
8. Summarize the effects of light energy on carbon dioxide utilization in photosynthesis.
9. Summarize the filter paper chromatography of chlorophyll extract as concerns the separation of the pigments involved.
10. Contrast cyclic and noncyclic photophosphorylation. Describe how proton gradients form ATP according to the chemiosmotic theory.
11. Describe the biological significance of photosynthesis in terms of light energy, chlorophyll, photophosphorylation, coenzyme, and ATP.

VOCABULARY

(In addition to the terms underlined on front.)

ADP
Calvin cycle
carbon fixation
carotenes
epidermis
fluorescence
grana
guard cells
Hill reaction
high energy compounds
hydrogen ion reservoir
inorganic phosphate
intercellular air space
mesophyll
NAD
NADH
NADP
NADPH
nanometer
oxidation
oxidation/reduction reactions
palisade parenchyma
phosphate group
phosphorylation (oxidative, photo, and substrate)
photolysis
photon
photosystems I and II
pigment
reaction center
reduction
Rf value
spongy parenchyma
stoma (stomata)
stroma
thylakoid
xanthophylls

APPENDIX D

BIOLOGY 110, COURSE OBJECTIVES, UNITS F-P

UNIT F, CHEMICAL PROCESSES OF LIFE , PART III
CELLULAR RESPIRATION

Reading Assignments in Davis and Solomon: pages 137-152.
Reading Assignment in Eberhard: pages 67-74.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Write a summary reaction for cellular respiration, giving the origin and fate of each substance involved and the biological significance of respiration.
2. Define, compare, and contrast anaerobic and aerobic respiration pathways.
3. Summarize the events of glycolysis, lactate fermentation, alcoholic fermentation, and the Krebs citric acid cycle, giving the key organic compounds formed and the number of carbon atoms in each; indicate the number of ATP molecules used and produced and the transactions in which hydrogen loss occurs.
4. Identify the cellular sites for glycolysis, lactate fermentation, alcoholic fermentation, and the Krebs citric acid cycle. Which is (are) anaerobic? Aerobic?
5. Define the function of ATP in glycolysis and respiration.
6. Summarize the operation of the electron transport system, including the reactions by which a gradient of protons is established across the inner mitochondrial membrane; explain how the proton gradient drives ATP synthesis.
7. Reserved.
8. Apply the principles of energy utilization to explain the processes of glycolysis, alcoholic fermentation, lactate fermentation, and cellular respiration.
9. Summarize the events of the citric acid cycle, beginning with the conversion of pyruvate to acetyl-CoA; indicate the fate of carbon-oxygen segments and of hydrogens removed from the fuel molecule.
10. Compare aerobic respiration with anaerobic pathways in terms of ATP formation, final hydrogen acceptor, and end products; give two specific examples of anaerobic pathways.
11. Summarize the principles and concepts of cellular respiration by generalizing the role of ATP and other phosphorylated compounds in derivation of energy from nutrient molecules.

VOCABULARY

(In addition to the terms underlined above.)

acetyl coenzyme A
acetyl group
ADP
chemiosmosis
citrate
coenzymes
cytochrome systems
FAD
FADH2
inorganic phosphate
metabolism
NAD
NADH+ + H+
oxidation
oxidative phosphorylation
PGAL
phosphate group
pyruvate
reduction

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UNIT G, GENETICS

Reading Assignments in Davis and Solomon: pages 686-688, 156-175, and 176-198. Reading Assignment in Eberhard: pages 75-96.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Contrast the events and results of mitosis and meiosis.
2. Cite the similarities and differences between spermatogenesis and oogenesis.
3. Describe the events occurring in each stage of meiosis with emphasis on the behavior of chromosomes.
4. Distinguish between haploid and diploid and define homologous chromosomes.
5. Define synapsis, tetrad formation, and crossing-over and the stages of meiosis in which these phenomena occur.
6. Summarize the concepts of homologous chromosomes and allelic genes.
7. Define and explain the terms fertilization, zygote, and spore.
8. Describe the structure of a chromosome and give the function of a gene.
9. Identify the stages in the cell cycle and describe the main events of each.
10. Define the basic terms relating to genetic inheritance, for example, gene, dominance, recessiveness, codominance, chromosome, chromatid, homozygous, heterozygous, alleles, homologous, genotype, and phenotype.
11. Relate the inheritance of genetic traits to the behavior of chromosomes in meiosis.
12. Construct and complete a Punnett square to demonstrate how this tool can be used to predict genotypic and phenotypic ratios among offspring from a cross.
13. Solve simple problems in genetics involving genotypes and phenotypes of monohybrid and dihybrid crosses by applying Mendel's laws.
14. Solve simple problems in genetics involving incomplete dominance, polygenes, and multiple alleles.

15. Recognize a state of genetic linkage and, given an example, be able to solve simple genetic problems involving sex linkage.

16. Explain how the cross Aa x aa (where A and a are two alleles at an autosomal locus and the allele A is completely dominant) is a test cross.

17. Explain what is meant by codominance and how it differs from complete dominance and how, if in any way, codominance differs from intermediate inheritance.

18. Identify the gametes and genotypes involved in a cross of AABB x aabb and in a cross of AaBb x AaBb.

19. Construct and complete a Punnett square to demonstrate how this tool can be used to predict genotypic and phenotypic ratios in a dihybrid cross.

20. Describe how the law of independent assortment applies to the types of crosses given in objectives 18 and 19.

21. Reserved.

22. Explain the inheritance pattern of the human X and Y chromosomes.

23. Distinguish between homozygous and heterozygous genotypes. Relate genotype to phenotype in terms of dominance.

24. Describe the inheritance of sex-linked genes.

25. Explain how sex linked inheritance differs from autosomal inheritance.

26. Explain how the expected genotypic and phenotypic ratios involved will differ if a trait is inherited as a sex linked trait as compared to an autosomal trait.

27. Describe the inheritance of the Rh and ABO factors and outline the mechanisms of Rh disease.

28. Define the terms linkage group and chromosome map.

29. Summarize the characteristics of selected genetic diseases and selected chromosomal disorders.

30. Successfully complete the assigned laboratory work involving genetic studies with Drosophila.

UNIT G, GENETICS

VOCABULARY --IN ADDITION TO THE TERMS UNDERLINED ABOVE

albino
autosomes
centromere
differentiation
egg
embryo
erythroblastosis fetalis
fertilized egg
flagellum
gametogenesis
gametophyte
genetic cross
histones
hybrid
interkinesis
law of dominance
laws of inheritance
law of segregation
locus
mutation
nucleosomes
oogonia
ovary
ovum
polar bodies
primary oocyte
primary spermatocyte
progeny
pronucleus
pure-breeding strain
secondary oocyte
secondary spermatocyte
sex chromosome
somatic cell
sperm
spermatid
sporophyte
testis
true-breeding strain

BIOLOGY 110/110N

UNIT E, PLANT AND ANIMAL REPRODUCTION AND DEVELOPMENT

Reading Assignment in Davis and Solomon: pages 61-62, 169-171, 351-408, and 634-682. Reading Assignment in Eberhard: 215-226 and 275-284.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Define growth, morphogenesis, and cellular differentiation, and describe the role of each process in the development of an organism.
2. Discuss the adaptive advantages and disadvantages of both sexual and asexual reproduction. Give two specific examples of asexual reproduction.
3. Describe two methods of asexual reproduction in plants.
4. Compare sexual reproduction in gymnosperms and in angiosperms.
5. Describe the events leading to and including fertilization of an ovum (egg).
6. Describe the role of an egg and sperm during fertilization.
7. Compare and contrast the terms cleavage and growth.
8. Compare and contrast successive stages of seastar and frog development.
9. Describe the stages of development including the stages from the one-cell stage to the 16-cell stage, the blastula, the gastrula, the implantation of the zygote, and the development of the placenta, and give the functions of the placenta and the amnion.
10. Name and locate the three primary germ layers.
11. Describe a typical angiosperm flower and identify its parts, using appropriate scientific terminology.
12. Describe the production of pollen and ovules in angiosperms, and summarize the process of fertilization as it occurs in such plants.
13. Outline the adaptive significance of fruits and summarize the process by which they are formed.

14. Give the main structural features of typical monocot and dicot seeds.

15. Describe apical (primary) meristems and lateral (secondary) meristems and their derivatives.

16. Explain, compare, and contrast animal and plant development.

17. Describe the functions of testosterone, follicle-stimulating hormone, and luteinizing hormone in humans.

18. Trace the development of sperm cells and their passage through the male reproductive system, labeling on a diagram each male structure and giving its function.

19. Describe or label on a diagram each structure of the female reproductive system and give its function.

20. Use a diagram to explain how the process of meiosis results in the formation of sperm with the haploid number of chromosomes.

21. - 22. Reserved.

23. Trace the development and fate of the ovum.

24. Describe the hormonal control of the menstrual cycle including an explanation of the various hormones involved (FSH, LH, estrogen, human chorionic gonadotropin [HCG], and progesterone) and identify the timing of important events such as ovulation and menstruation.

25. Describe the preformation theory and the theory of epigenesis, and relate these theories to current concepts of development.

26. Reserved.

27. Describe the process of fertilization and list its functions. Identify the time of the menstrual cycle at which sexual intercourse is most likely to result in pregnancy.

28. Describe the mode of action and give the advantages and disadvantages of each of the following methods of contraception: the Pill, IUD, spermicides, condom, diaphragm, rhythm, douche, withdrawal, and sterilization.

29. Locate and describe the function of the following structures of a developing human embryo: umbilical cord, placenta, yolk sac, amnion, amniotic fluid, and lanugo.

30. Describe the general course of the later development of the human being, from one month after conception until the time of birth.

31. List at least five changes in the baby's immediate environment and also body functions that occur with the birth of the child.

UNIT H, PLANT AND ANIMAL REPRODUCTION AND DEVELOPMENT

VOCABULARY

(In addition to the underlined terms in the learning objectives.)

abort (miscarry)
acrosome
allantois
anterior pituitary
anther
archenteron (gastrocoel)
auxin
blastodermic disc
bulbourethral glands
cambium
cervix
chorion
contraceptive methods
copulation
corpus luteum
cotyledons
ectoderm
embryology
endoderm
endometrium
endosperm
epididymis
fallopian tube
fetal membranes
fertilization cone
fetus
filament
follicle
fusion nucleus
gametogenesis
gametophyte
generative nucleus
implantation
interstitial cells
megagametophyte
megasporangium
megaspore
megaspore mother cell
mesoderm
microgametophyte
microsporangia
microspore
microspore mother cell
morula
oogenesis
ovary
oviduct
parthenogenesis
penis
pistil
pituitary gland
plumule
polar body
polar nuclei
pollen grain
pollen tube
pollination
primary oocyte
primary spermatocyte
primary tissue
pronucleus
prostate gland
radicle
scrotum
secondary oocyte
secondary spermatocyte
secondary tissue
semen
seminal vesicles
seminiferous tubules
somatic cells
spermatid
spermatogenesis
spermatogonia
sperm nucleus
stamen
stigma
style
suspensor
testis
triploid zygote
tube nucleus
urethra
uterus
vagina
vas deferens
vasectomy

BIOLOGY 110/110N

UNIT I, EVOLUTION AND ADAPTATION

Reading Assignments in Davis and Solomon: pages 4-25, 685-723.
Reading Assignment in Eberhard: 107-114.

LEARNING OBJECTIVES

After you have studied the material of this unit, you will be able to:

1. Discuss the history of evolutionary thought (with emphasis on Charles Darwin), listing the most important contributors (such as Jean Baptiste de Lamarck, A. R. Wallace, etc.) and summarizing their ideas.
2. Explain how variation, competition, and subsequent selection are relevant to Darwin's theory of evolution.
3. Define organic evolution in genetic terms and distinguish between microevolution and macroevolution.
4. Define the terms population, gene pool, differential reproduction, species, and reproductive isolation and explain how a given species could evolve into two species.
5. Explain why evolution is a phenomenon related to populations rather than to an individual.
6. State the Hardy-Weinberg law and the conditions under which it applies and discuss its significance and consequences in terms of population genetics and evolution.
7. Determine the frequencies of the two alleles in a sample from a population assumed to be in Hardy-Weinberg equilibrium.
8. Given the allelic frequencies of a population assumed to be in Hardy-Weinberg equilibrium, calculate the expected frequencies of the genotypes involved.
9. Explain why variations among individuals of the same species may result from differences in environment and differences in genetic make-up.
10. Summarize the "modern" concept of evolution (neo-Darwinism), discuss its mechanisms (mutation, genetic recombination, genetic drift, natural selection, reproductive isolation, etc.) and the adaptive results, and cite specific examples and illustrative experiments.
11. List at least four isolating mechanisms that enable closely related species to remain separate.
12. Write a short explanation of the terms divergent evolution, adaptive radiation, convergent evolution, parallel evolution, primitive organism, advanced organism.

VOCABULARY

(In addition to the underlined terms given above.)

abiogenesis
allopatric speciation
analogous
behavioral isolation
biogeography
carnivore
embryonic lethality
emigration
endemic species
endosymbiotic theory
environmental variation
extinction
fossil
gene exchange
geographic isolation
habitat
habitat isolation
herbivore
homologous
hominids
hybrid sterility
immigration
inheritance
interbreeding
inviable
mechanical reproductive isolation
migration
mimicry
panmictic
prezygotic isolating mechanisms
postzygotic isolating mechanisms
races
seasonal isolation
selective breeding
speciation
stabilizing selection
structural parallelism
survival of the fittest
sympatric speciation
vestigal structures
viable

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APPENDIX E

BIOLOGY 110, LABORATORY EXERCISE LIST

List of Laboratory Exercises for Biology 110 in Eberhard

- Unit A - Microscopy and Levels of Organization, p. 13-18
  - Live amoeba demo, lab bench
  - Amoeba film loop, lab bench
  - Live slime mold demo, lab bench
  - How to use the stereomicroscope, p. 13-14
  - Viewing a prepared slide, p. 16
  - Computing magnification, p. 16-17
  - Measuring objects, p. 17
  - Preparing a wet mount, p. 17-18
  - Studying biological organisms, p. 18

- Unit B - Cellular Organization and Function, p. 19-31
  - Onion epidermis, p. 20-21, 25
  - Human cheek cells, p. 21
  - Animal cell mitosis, p. 21-23
  - Plant cell mitosis, p. 23-26
  - Diffusion of a liquid in a liquid, p. 28
  - Diffusion in a solid, demo, p. 28-29, 31
  - Osmosis in a model cell, demo, p. 29, 31
  - Osmosis in a living cell, p. 29-30

- Unit C - Composition of Living Matter, p. 1-11
  - Benedict's test, p. 2-3, 9
  - Iodine test, p. 3, 9
  - Sudan III test, p. 3-4, 9
  - Biuret test, p. 4, 9
  - Testing unknowns, p. 4, 10
  - Amino acid chromatography, demo, p. 4-7, 11

- Unit D - Chemical Processes of Life I (DNA, RNA, & Protein Syn.), p. 43-52, 115-122
  - Kinetics of the peroxidase reaction, p. 44-47, 49-52
  - DNA in giant chromosomes, demo, p. 117
  - Regulation of the lactose operon, p. 117-119, 121-122

- Unit E - Chemical Processes of Life II (Photosynthesis), p. 53-66
  - Photosynthetic pigments: chromatography, p. 53-55, 61
  - Photosynthetic pigments: absorption spectrum, p. 55-56, 62
  - Photosynthesis in elodea, p. 56-57, 63
  - The Hill reaction, p. 57-58, 64-66
  - Carbon fixation, p. 58

- Unit F - Chemical Processes of Life III (Respiration), p. 67-74
  - Fermentation in yeast, p. 68, 73
  - Respiration in plants and animals, p. 68-69, 74
  - The electron transport chain, p. 70, 74

Unit G - Genetics, p. 75-83, 85-95
  Mitosis in yeast, p. 76
  Mechanics of mitosis and meiosis, p. 76-78, 81-83
  Meiosis in an animal cell, demo, p. 78-80
  Sperm cells of bull, demo, p. 80
  Morphology, demo, p. 86-89
  The genetics experiment, demo, p. 89-90
  Analysing the crosses, p. 90, 93-95

Unit H - Reproduction and Development, p. 215-226, 275-283
  Flowers, p. 216, 223-224
  Pollen, p. 217
  Ovulary, p. 217-218, 224
  Fruit, p. 218-219, 225
  Seeds, p. 219
  Germination, p. 220
  Asexual reproduction, p. 220-221, 226
  Female reproductive system, p. 277-278
  Male reproductive system, p. 278-279
  Human reproduction: conception, p. 280
  Human reproduction: contraception, p. 280-283

Unit I - Evolution and Adaptation, p. 107-113
  Taste test, p. 108, 111
  Natural selection, p. 108-110, 112
  Negative eugenics, p. 110, 113

Unit J - Ecology, two laboratory handouts
  Didinium and Paramecium predator-prey demo, handout
  Energetics of an aquatic ecosystem, handout

APPENDIX F

HANDOUT ENTITLED "HOW TO INTERPRET YOUR SCORE ON THE LEARNING STYLE PROFILE"

HOW TO INTERPRET YOUR SCORE
ON THE *LEARNING STYLE PROFILE*

Marlin Languis: Co-author, *Learning Style Profile*
Professor, Educational Theory and Practice
Director, Brain Behavior Laboratory

in cooperation with

Russell Skavaril: Professor, Molecular Genetics
Director, General Biology Program

Claudia Melear: Graduate Research Associate
General Biology Program

Instructions:

The information below will help you understand the meaning of your computer printout from the *Learning Style Profile* (LSP) that you took earlier this quarter. The LSP provides introductory level information about 23 components (called subscales) of your learning style. It is designed to help you understand your learning style strengths and preferences and to suggest areas in which you may wish to improve your study and learning in Biology.

We suggest that you look carefully at the scores for subscales that are at the extreme right or left of your LSP sheet; however, you should not interpret high or low scores as "good" or "bad". Instead, we would suggest that you take time to use the LSP profile information to think about the way you go about studying and learning in this course. You may agree or disagree with some of the LSP results. The goal is to help you get a better "handle on" the way/s you learn and study best and to get some suggested areas for improvement.

---COGNITIVE SKILLS, GENERAL APPROACH TO PROCESSING INFORMATION---

1. Analytic Skill

A score on the strong side of the profile suggests you have a strength in analytic thinking. A strong score indicates you have skill in logically breaking down complex information into its essential subcomponents. You can see the major points and the subpoints under them. You can pick out key ideas and not be easily influened by other less important or irrelevant details in reading a chapter or listening to a lecture. Other things being equal, you usually can take good notes from reading the Biology course text or from Dr. Skavril's taped lectures. A score in the weak section suggests that it may be difficult for you to break down information into subparts without missing important points or getting a bit confused.

2. Spatial Skill

The spatial skill area assesses the strength of your skill in mentally visualizing and manipulating tasks which have two or three dimensional forms. A score on the strong side of the LSP suggests that you can rather easily manage to move or change these forms in your mind and keep track of them. You can mentally see how the forms or parts of them interrelate. Students sometimes describe this skill as "watching silent movies" inside your head. Getting information from diagrams or graphs in your biology textbook may also tap your spatial skill. "Seeing" patterns in tables of data or correlations is aided by spatial skill. It may also be helpful to "see" (or image) a web of ideas from listening to a lecture or reading a chapter.

3. Discrimination Skill

The discrimination skill area measures your skill in focusing on the important aspects of a task and not being distracted by irrelevant or unimportant information. A strong score suggests that you can concentrate and focus your attention well when required to do so. You may be able to rather easily "zero in" on key information and not get "sidetracked" by unimportant details. As a rule, you may be able to stick to a task and shut out distractions although certain environmental factors may be especially helpful or bothersome (See the last 5 subscales on the LSP).

4. Categorizing Skill

If your score in the categorizing area is on the strong side it suggests that you have skill in classifying objects or ideas flexibly into useful and reasonable groups. Categorizing skill is extremely useful in organizing new biology information from reading, tapes and from your recitations as you put it into your memory. You can consciously mentally "fit" the new information under related topics you have learned earlier; or you may need to create a new category for information. Categorizing skill is a great aid to memory. Categorizing mentally is a logical process very much like taking written notes in outline form.

5. Sequential Processing

A strong score on this subscale indicates you are skilled at processing and thinking about information in a step-by-step, linear and temporal order. Thinking sequentially is easy to describe in a step by step manner. Usually, planning and organizing is aided by thinking sequentially. On the other hand, one cannot easily deal with all the steps mentally at one moment. One must think about them in order. Many students (though not all) typically process verbal tasks and arithmetical calculation tasks sequentially while spatial tasks are often processed as a whole, simultaneously.

6. Memory Skill

The items on the memory portion of the LSP required you to hold the details of the figure from the previous page briefly in your memory. A score on the strong side of the LSP for this subscale indicates strength in short term memory for spatial information and attention to detail. Effective memory strategies are very crucial to effective learning in any course. To assess your memory skill completely is very complex and would require measuring both short and long term memory, encoding, storing and retrieval processes, and assessment of several memory strategies. Because these items assessed only short term memory, it may be useful for you to reflect on how you scanned the information in the diagrams to pick up and hold the information in your memory.

---PERCEPTUAL RESPONSES---

7-9. Perceptual Responses: Visual, Auditory, Emotive

The items on this subscale were designed to assess your tendency to respond initially to 20 words as you read them by mentally seeing a picture (a visual response); by mentally hearing the word (an auditory response); or by sensing an emotion (an emotive response). A strong LSP profile score on the strong side of the profile for one of the three perceptual responses suggests a tendency for you to respond to words as you read them in that manner. It may be that you tend to code words in your mind initially as you read them in the perceptual modality with the strongest score. Keep in mind that, for these items, your experience was reading words. You may respond to other types of experiences with a different perceptual modality strength. In addition to thinking about how you respond perceptually to various experiences, you may wish to consider whether you feel you learn more readily when information is presented in one or another sensory modalities.

---ORIENTATIONS AND PREFERENCES---

10. Persistence Orientation

The higher the score on this subscale the greater is your tendency to 'stick to a task' and get it done in the face of some difficulty; the lower the score, the less is your tendency to stick to a difficult task.

11. Verbal Risk Orientation

A score on the high side of the LSP profile for items in this subscale suggests that you are willing to talk, recite, ask questions or express your opinions in class even if you feel others may disagree with you.

12. Manipulative Preference

The higher score on this subscale, the higher your preference for hands-on, direct manipulation of actual materials in learning activities.

13-16. Study Time Preference: Early Morning, Late Morning, Afternoon, or Evening

Items on this subscale are designed to assess your preference for a particular time of day for studying or instruction. A high preference for one time of day and a low preference for a different time of day may indicate the time of day you are most energetic and alert. That time of day may be your best time for concentrated study and instruction.

17. Verbal-Spatial Preference

Items on this subscale indicates your tendency to organize information by the task's spatial or verbal features. Verbal task information is characterized by words and language features. Spatial aspects of a task are characterized by visual, pictorial or graphic dimensions.

18. Grouping Preference

If your score falls on the right side of the profile, you show preference for learning in a whole class situation, while a score in the middle suggests your preference of study in smaller groups, and a score on the left side of the profile indicates you may wish to study and learn alone or with one other person.

22. Lighting Preference

The score on this subscale indicates your preference for studying or learning in a brightly lighted area or in a dimly lighted enviroment.

20. Mobility Preference

This LSP subscale assesses your preference for moving about or remaining quiet while you are working and studying.

19. Posture Preference

The items on this subscale indicate your preference for formal study position (sitting up in a chair or desk) or for informal, casual positions while studying.

21. Sound Preference

The items on this subscale assess how high your preference is for a quiet or a noisy environment in which to study or learn. Types of background noise in a learning or study environment may include music, voices, or environmental sounds.

23. Temperature Preference

A high score on these subscale items indicates your preference for either a warmer environment to study or a preference for a cooler study or instructional environment.

APPENDIX G

INSTRUCTIONS FOR ADMINISTRATION OF THE LEARNING STYLE INSTRUMENTS FROM CLASS AGENDA

BIO-CMI AGENDA
Thurs/Fri Week 1 (Unit A)
1/7/88 or 1/8/88

1. Are there any students here for the first time today?

    a. Check schedule cards and ID and mark your class roster with a "P" for the students who arrived today.

    b. Give all new arrivals the 3 handouts from the first class (syllabus, "Facilities, Policies and Procedures" and List of Laboratory Exercises). These should be read thoroughly today. --And BLC work should be started today.

    c. Have all new arrivals fill out white class cards. Follow same procedure as last class.) We must have a white card for everyone.

    d. Remind people who are "sitting in" to call 2-9761 anytime Friday, (Jan. 8) or Monday (Jan. 11) to see if they have permission to add and at what time (or get section change).

2. Pass around "2-page" attendance sheet. Give same instructions as on 1st day. Make sure late arrivals get on the attendance sheet.

3. Remind everyone not to miss the "Orientation on How to Sign-on the Computer and Take Tests" next Tues/Wed (Jan. 12/13). If they have to miss your class they should attend another class the same day. (Anyone who misses Tues/Wed had better have a good excuse. We have no interest in giving 1:1 orientations to people who are too lazy to get to class!!)

    T/R and 110N students will be able to test for the first time on Tuesday, (January 12); W/F students on Wednesday (January 13). If you know the material, it will not take long to complete a test.

4. Administer the Learning Style Profile.

    Distribute to each student a LSP booklet, pencil and answer sheet. The LSP answer sheets are titled "NASSP Learning Style Profile." Have the students fill out the requested information on the answer sheet according to the directions you have been given. Tell your students their class area number. (It is listed on the left side of your sheet titled the "Class and Sign-on # Information.") Allow the students the entire class period to complete the inventory.

    While the students are taking the inventory, it would be a great time for you, also, to take the inventory if you haven't already done so. All the exams will be sent off to be scored at the end of the week; therefore, all tests must be completed this week.

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At the end of the class period, collect LSP booklets, pencils and answer sheets. Pass out to each student the Myers-Briggs Type Inventory and an answer sheet titled "General Purpose -NCS- Answer Sheet." At the next class period, the student must return the MBTI and the completed answer sheet. Follow the directions as to who gets the LSP booklets and pencils, but deliver the completed answer sheets and all extra MBTI materials to Mary Finnen immediately after recitation.

Announce to the students that the results of the LSP and MBTI will be given in class, but an explanation of the results will be given on February 16 and 17 at five different times. The times and locations of these sessions will be announced at a later date.

INSTRUCTORS:

1. The Testing Center will be unavailable for use Friday, January 8, from 1-4 p.m.

2. Reminder: With the Units Dialing System the Non-Emergency Police Number is:

   2-2121

   For Emergency assistance: 911

3. After class, PLEASE return extra handouts to the bookshelf in RH 52 or to RH 60.

4. Recitation instructors: Remember, T/R and 110N recitation instructors will meet at 2:30 p.m. in RH 52 today to decide who gets in to what class. W/F recitation instructors will meet with Mary Finnen in RH 60E on Jan. 8 after your recitation. Please:
   1) bring white class cards in alphabetical order
   2) bring class rosters and attendance sheets (both blue and yellow)
   3) make sure you have a white class card for EVERY signature that appears on either attendance sheet, on either day
   4) bring Class and Sign-On # Information Sheet

5. There is a key available in RM 060 for your use in opening the modules in the morning. See Cathy, Maureen, or Barbara.

6. The computers in RH 38 & 40 are available for your use. You may use them to look up your students' performance records, read your student mail, and etc. Your key to RH 52 should unlock rooms 38 and 40. If you haven't picked up a key for RH 52, you may pick up a key from Cathy Creager in RH 60.

7. Any further schedule changes for teaching assignments? If not, a master schedule will be typed and posted. Check the

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8. Resist the temptation to dismiss class early. Dismissing class early, whether it be 10 minutes or 5 minutes or 30 minutes, only reinforces to the students that they do not have to be prepared for class discussion. When their questions run out, you ask them questions. Although it is difficult at times to remain enthusiastic and/or fill the time, but keep in mind that those students attending recitation deserve your best and full attention. Even if it is only one student who is there to learn, that one student does not deserve to be slighted. You are all good instructors, so you can meet this challenge.

9. Reminder: Testing Center opens Tuesday, Jan. 12 at 8:30 a.m.

10. You should make a general statement reminding students with learning disabilities to identify themselves to you. We have means of accomodating such a student. Once a student has indicated a problem, send the student to Mary Finnen (RH 060E).

11. Three reminders about testing procedure:

    a. Students should be encouraged to complete a test if they start one, but if they must leave for another class or appointment, use "Option A" (restart at next question). "Option B" should not be used. If a student tries to get you to cancel a test because too many questions have been missed, tell the student "you cannot do it" and that they are committed to that test and that try.

    b. Do not "look up" questions for students who come to you with question IDs. Use the ID information to find out unit and objective, and then discuss the objective with the student. If the student wants to describe the question to you, that's OK, but no instructor should be showing questions off the screen or printing questions for students.

    c. Remember to fill out the green problem sheets completely and place them in Mary Finnen's folder in RH 52.

12. REMEMBER TO AUTOMATICALLY LOCK THE DOOR AFTER YOU HAVE LET YOURSELF IN THE ROOM. DOORS TO RH 38, 40, 52 (Testing Center), AND 34 (TA Lounge) SHOULD ALWAYS BE LOCKED.

13. The following people need to turn in the green phone information sheet: Artigas, Burns, Ishikawa, Kim, Lazo, Lee, Ann Martin, Palmieri, Park, Rojas, True, Walker, Wang, Wu, and Yee.

[illegible]

APPENDIX H

ADMISSIONS VARIABLES COLLECTED BUT NOT USED FOR THE STUDY

TABLE 43

ADMISSIONS VARIABLES COLLECTED BUT NOT USED IN THE STUDY

Name	Description	Database		
		1 LSP	2 MBTI/CMI	3 Admissions
ACTCOM	Composite score on ACT			X
ACTENG	English score on ACT			X
ACTM	Math score on ACT			X
ACTNS	Natural science score on ACT			X
ACTPGPA	Predicted GPA on ACT			X
ACTSOS	Social science score on ACT			X
Colg	College			X
Day	Birthday day of subject	X		
GPA	Grade point average during quarter taking Biology 110			X
Major	Subject's college major			X
Mo	Birthday month of subject	X	X	
Name	Subject's name			X
Race	Subject's race			X
SATM	SAT math score			X
SATR	SAT reading score			X
SATT	SAT TSWE score			X
SATV	SAT verbal score			X
Yr	Birth year of subject	X		

APPENDIX I

BASIC PROGRAM LISTING FOR SCORING MBTI; NCS ANSWER SHEET AND MBTI REPORT

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10 REM *******************************************************
20 REM Program Name:         MBS
30 REM
40 REM  Program to Score The Myers-Briggs Type Indicator.
50 REM
60 REM Language:  BASIC    (GWBASIC/NCR  BASICA/IBM)
70 REM
80 REM Written by:  Russell V. Skavaril
90 REM                       and
100 REM             Claudia T. Melear
110 REM General Biology, The Ohio State University
120 REM Columbus, Ohio           December, 1988.
130 REM
140 REM *******************************************************
150 REM
160 REM
170 REM
180 DIM R(126), PAT$(8)
190 CLS
200 PRINT "Input quarter and year, for example:"
210 PRINT CHR$(34)+"AUTUMN QUARTER 1988"+CHR$(34)
220 PRINT "Note -- data enclosed in quotation marks."
230 INPUT "Data"; QY$
240 CLS
250 PRINT "Input name of student, for example:"
260 PRINT CHR$(34)+"Rogers, Sally A."+CHR$(34)
270 PRINT "Note -- data enclosed in quotation marks."
280 INPUT "Data"; NNAME$
290 CLS
300 PRINT "Input sex of student."
310 PRINT "Enter 1 if student is a male."
320 PRINT "Enter 2 if student is a female."
330 INPUT "Data"; SEX
340 CLS
350 PRINT "Input Social Security Number, with dashes, for example:"
360 PRINT CHR$(34)+"123-45-6789"+CHR$(34)
370 PRINT "and also enclosed in quotation marks."
380 INPUT "Data"; SSN$
390 CLS
400 PRINT "Input section identification data."
410 PRINT "For example:
420 PRINT CHR$(34)+"W/F, 11:00 a.m., Rm. 124 RH, Mr. Gilles"+CHR$(34)
430 PRINT "with data enclosed in quotation marks."
440 INPUT BSEC$
450 CLS
460 PRINT "Enter responses to items as called for by program."
470 PRINT "Responses are NOT enclosed in quotation marks."
480 FOR I=1 TO 126
490 PRINT I;
500 INPUT R(I)
510 PRINT
520 NEXT I
530 SEXC$="      "
540 IF SEX=1 THEN SEXC$="MALE  "
550 IF SEX=2 THEN SEXC$="FEMALE"
560 REM  Allow data editing.
570 CLS: PRINT "ITEM NUMBER/RESPONSE"
580 FOR I=1 TO 20
590 PRINT USING "####"; I;:NEXT I: PRINT
600 FOR I=1 TO 20
610 PRINT USING "####"; R(I);
620 NEXT I
630 PRINT
640 PRINT
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640 PRINT
650 FOR I=21 TO 40
660 PRINT USING "####"; I;: NEXT I: PRINT
670 FOR I=21 TO 40
680 PRINT USING "####"; R(I);
690 NEXT I
700 PRINT
710 PRINT
720 FOR I=41 TO 60
730 PRINT USING "####"; I;: NEXT I: PRINT
740 FOR I=41 TO 60
750 PRINT USING "####"; R(I);
760 NEXT I
770 PRINT
780 PRINT
790 FOR I=61 TO 80
800 PRINT USING "####"; I;: NEXT I: PRINT
810 FOR I=61 TO 80
820 PRINT USING "####"; R(I);
830 NEXT I
840 PRINT
850 PRINT
860 INPUT "Are data O.K.?  (1 => yes, 2 => no)"; RESP
870 IF RESP<>1 THEN RESP=2
880 IF RESP=1 THEN GOTO 930
890 INPUT "ITEM NUMBER of response to be corrected"; I
900 I=INT(I): IF I<1 OR I>80 THEN GOTO 890
910 INPUT "Correct RESPONSE"; R(I)
920 GOTO 570
930 CLS: PRINT "ITEM NUMBER/RESPONSE"
940 FOR I=81 TO 100
950 PRINT USING "####"; I;: NEXT I: PRINT
960 FOR I=81 TO 100
970 PRINT USING "####"; R(I);
980 NEXT I
990 PRINT
1000 PRINT
1010 FOR I=101 TO 120
1020 PRINT USING "####"; I;: NEXT I: PRINT
1030 FOR I=101 TO 120
1040 PRINT USING "####"; R(I);
1050 NEXT I
1060 PRINT
1070 PRINT
1080 FOR I=121 TO 126
1090 PRINT USING "####"; I;: NEXT I: PRINT
1100 FOR I=121 TO 126
1110 PRINT USING "####"; R(I);
1120 NEXT I
1130 PRINT
1140 PRINT
1150 INPUT "Are data O.K. (1 => yes; 2=> no)"; RESP
1160 IF RESP<>2 THEN RESP=1
1170 IF RESP=1 THEN GOTO 1230
1180 INPUT "ITEM NUMBER of response to be corrected"; I
1190 I=INT(I)
1200 IF I<81 OR I>126 THEN GOTO 1180
1210 INPUT "Correct RESPONSE"; R(I)
1220 GOTO 930
1230 E=0
1240 REM FOR THE E SCORE
1250 IF R(3)=1 THEN E=E+2
1260 IF R(7)=1 THEN E=E+1
1270 IF R(10)=1 THEN E=E+2
1280 IF R(13)=2 THEN E=E+2
1290 IF R(16)=2 THEN E=E+2
1300 IF R(19)=1 THEN E=E+2
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1310 IF R(23)=1 THEN E=E+1
1320 IF R(26)=1 THEN E=E+1
1330 IF R(31)=1 THEN E=E+1
1340 IF R(37)=2 THEN E=E+2
1350 IF R(40)=2 THEN E=E+1
1360 IF R(66)=1 THEN E=E+1
1370 IF R(68)=1 THEN E=E+1
1380 IF R(72)=1 THEN E=E+1
1390 IF R(75)=2 THEN E=E+2
1400 IF R(79)=1 THEN E=E+1
1410 IF R(81)=2 THEN E=E+1
1420 IF R(86)=1 THEN E=E+1
1430 IF R(90)=1 THEN E=E+1
1440 REM FOR THE I SCORE
1450  I=0
1460 IF R(3)=2 THEN I=I+2
1470 IF R(7)=2 THEN I=I+2
1480 IF R(10)=2 THEN I=I+2
1490 IF R(13)=1 THEN I=I+1
1500 IF R(16)=1 THEN I=I+1
1510 IF R(19)=2 THEN I=I+2
1520 IF R(23)=2 THEN I=I+1
1530 IF R(31)=2 THEN I = I+2
1540 IF R(37)=1 THEN I=I+1
1550 IF R(40)=1 THEN I=I+1
1560 IF R(55)=2 THEN I=I+1
1570 IF R(66)=2 THEN I=I+1
1580 IF R(72)=2 THEN I=I+1
1590 IF R(75)=1 THEN I=I+1
1600 IF R(77)=2 THEN I=I+2
1610 IF R(79)=2 THEN I=I+2
1620 IF R(81)=3 THEN I=I+2
1630 IF R(86)=2 THEN I=I+1
1640 IF R(90)=2 THEN I=I+2
1650 REM FOR THE N SCORE.
1660 N =0
1670 IF R(2)=2 THEN N=N+2
1680 IF R(5)=1 THEN N=N+2
1690 IF R(9)=2 THEN N=N+2
1700 IF R(11)=2 THEN N=N+2
1710 IF R(18)=1 THEN N=N+1
1720 IF R(25)=2 THEN N=N+1
1730 IF R(29)=2 THEN N=N+1
1740 IF R(33)=2 THEN N=N+1
1750 IF R(42)=1 THEN N=N+2
1760 IF R(44)=2 THEN N=N+1
1770 IF R(58)=2 THEN N=N+2
1780 IF R(61)=2 THEN N=N+1
1790 IF R(63)=2 THEN N=N+2
1800 IF R(65)=1 THEN N=N+2
1810 IF R(71)=2 THEN N=N+1
1820 IF R(83)=1 THEN N=N+2
1830 REM FOR S SCORE.
1840 S=0
1850 IF R(2)=1 THEN S=S+2
1860 IF R(5)=2 THEN S=S+1
1870 IF R(9)=1 THEN S=S+2
1880 IF R(11)=1 THEN S=S+1
1890 IF R(18)=2 THEN S=S+2
1900 IF R(22)=2 THEN S=S+1
1910 IF R(25)=1 THEN S=S+1
1920 IF R(29)=1 THEN S=S+2
1930 IF R(33)=1 THEN S=S+2
1940 IF R(42)=2 THEN S=S+1
1950 IF R(44)=1 THEN S=S+1
1960 IF R(46)=2 THEN S=S+2
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1970 IF R(48)=1 THEN S=S+2
1980 IF R(50)=1 THEN S=S+2
1990 IF R(52)=1 THEN S=S+1
2000 IF R(58)=1 THEN S=S+1
2010 IF R(61)=1 THEN S=S+2
2020 IF R(67)=1 THEN S=S+1
2030 IF R(69)=1 THEN S=S+1
2040 IF R(71)=1 THEN S=S+1
2050 IF R(80)=2 THEN S=S+1
2060 IF R(83)=2 THEN S=S+1
2070 IF R(85)=2 THEN S=S+1
2080 IF R(91)=1 THEN S=S+2
2090 REM FOR J SCORE
2100 J = 0
2110 IF R(1)=1 THEN J=J+2
2120 IF R(4)=1 THEN J=J+2
2130 IF R(8)=2 THEN J=J+1
2140 IF R(12)=1 THEN J=J+2
2150 IF R(14)=1 THEN J=J+1
2160 IF R(17)=3 OR R(17)=5 OR R(17)=6 OR R(17)=7 THEN J=J+1
2170 IF R(20)=1 THEN J=J+1
2180 IF R(24)=1 THEN J=J+1
2190 IF R(27)=1 THEN J=J+2
2200 IF R(35)=1 THEN J=J+2
2210 IF R(39)=1 THEN J=J+2
2220 IF R(53)=2 THEN J=J+1
2230 IF R(57)=1 THEN J=J+1
2240 IF R(59)=2 THEN J=J+1
2250 IF R(62)=1 THEN J=J+2
2260 IF R(74)=2 THEN J=J+1
2270 IF R(78)=2 THEN J=J+1
2280 IF R(82)=2 THEN J=J+1
2290 IF R(84)=1 THEN J=J+2
2300 IF R(95)=1 THEN J=J+1
2310 REM FOR P SCORE
2320 P=0
2330 IF R(1)=2 THEN P=P+2
2340 IF R(4)=2 THEN P=P+1
2350 IF R(8)=1 THEN P=P+1
2360 IF R(12)=2 THEN P=P+2
2370 IF R(14)=2 OR R(14)=3 THEN P=P+1
2380 IF R(17)=1 OR R(17)=4 OR R(17)=6 THEN P=P+1
2390 IF R(20)=2 THEN P=P+2
2400 IF R(24)=2 THEN P=P+1
2410 IF R(27)=2 THEN P=P+2
2420 IF R(35)=2 THEN P=P+2
2430 IF R(39)=2 THEN P=P+2
2440 IF R(53)=1 THEN P=P+2
2450 IF R(57)=2 THEN P=P+1
2460 IF R(62)=2 THEN P=P+1
2470 IF R(64)=1 THEN P=P+1
2480 IF R(74)=1 THEN P=P+1
2490 IF R(76)=2 THEN P=P+2
2500 IF R(78)=1 THEN P=P+1
2510 IF R(82)=1 THEN P=P+1
2520 IF R(84)=2 THEN P=P+1
2530 IF R(88)=2 THEN P=P+1
2540 IF R(93)=2 OR R(93)=3 THEN P=P+1
2550 IF SEX=1 THEN GOTO 2950
2560 REM SCORE FOR T (FEMALE)
2570 T = 0
2580 IF R(6)=2 THEN T=T+2
2590 IF R(15)=2 THEN T=T+2
2600 IF R(21)=2 THEN T=T+2
2610 IF R(28)=2 THEN T=T+2
2620 IF R(30)=1 THEN T=T+2
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2630 IF R(32)=1 THEN T=T+2
2640 IF R(34)=1 THEN T=T+2
2650 IF R(36)=1 THEN T=T+1
2660 IF R(38)=2 THEN T=T+2
2670 IF R(41)=1 THEN T=T+1
2680 IF R(43)=1 THEN T=T+1
2690 IF R(45)=1 THEN T=T+2
2700 IF R(47)=2 THEN T=T+2
2710 IF R(49)=2 THEN T=T+2
2720 IF R(51)=2 THEN T=T+2
2730 IF R(54)=2 THEN T=T+1
2740 IF R(56)=2 THEN T=T+1
2750 IF R(60)=1 THEN T=T+2
2760 IF R(89)=1 THEN T=T+1
2770 IF R(92)=2 THEN T=T+1
2780 REM SCORE FOR F (FEMALE)
2790 F = 0
2800 IF R(6)=1 THEN F=F+2
2810 IF R(15)=1 THEN F=F+1
2820 IF R(21)=1 THEN F=F+2
2830 IF R(30)=2 THEN F=F+1
2840 IF R(32)=2 THEN F=F+1
2850 IF R(34)=2 THEN F=F+2
2860 IF R(36)=2 THEN F=F+2
2870 IF R(38)=1 THEN F=F+1
2880 IF R(41)=2 THEN F=F+1
2890 IF R(43)=2 THEN F=F+2
2900 IF R(56)=1 THEN F=F+1
2910 IF R(70)=1 THEN F=F+1
2920 IF R(73)=1 THEN F=F+2
2930 IF R(87)=1 THEN F=F+2
2940 GOTO 3340
2950 REM SCORE FOR T (MALE)
2960 T=1
2970 IF R(6)=2 THEN T=T+1
2980 IF R(15)=2 THEN T=T+2
2990 IF R(21)=2 THEN T=T+2
3000 IF R(28)=2 THEN T=T+2
3010 IF R(30)=1 THEN T=T+2
3020 IF R(32)=1 THEN T=T+2
3030 IF R(34)=1 THEN T=T+1
3040 IF R(36)=1 THEN T=T+1
3050 IF R(38)=2 THEN T=T+2
3060 IF R(41)=1 THEN T=T+1
3070 IF R(43)=1 THEN T=T+1
3080 IF R(45)=1 THEN T=T+2
3090 IF R(47)=2 THEN T=T+2
3100 IF R(49)=2 THEN T=T+2
3110 IF R(51)=2 THEN T=T+2
3120 IF R(54)=2 THEN T=T+1
3130 IF R(56)=2 THEN T=T+1
3140 IF R(60)=1 THEN T=T+2
3150 IF R(89)=1 THEN T=T+1
3160 IF R(92)=2 THEN T=T+2
3170 REM SCORE F (MALES)
3180 F=0
3190 IF R(6)=1 THEN F=F+1
3200 IF R(15)=1 THEN F=F+1
3210 IF R(21)=1 THEN F=F+2
3220 IF R(28)=1 THEN F=F+1
3230 IF R(30)=2 THEN F=F+2
3240 IF R(32)=2 THEN F=F+2
3250 IF R(34)=2 THEN F=F+2
3260 IF R(36)=2 THEN F=F+2
3270 IF R(38)=1 THEN F=F+1
3280 IF R(41)=2 THEN F=F+1
```

```
3290 IF R(43)=2 THEN F=F+1
3300 IF R(56)=1 THEN F=F+1
3310 IF R(73)=1 THEN F=F+1
3320 IF R(87)=1 THEN F=F+1
3330 REM SCORE FOR EI PREFERENCE.
3340 PRINT " "
3350 TYPE1$="E"
3360 IF I>=E THEN TYPE1$="I"
3370 IXSTART=1
3380 IF I>=E THEN IXSTART=0
3390 EISCORE=1
3400 FOR IX=IXSTART TO IXSTART+33
3410 IF ABS(E-I)=IX THEN GOTO 3440
3420 EISCORE=EISCORE+2
3430 NEXT IX
3440 PRINT TYPE1$, EISCORE
3450 REM SCORE FOR SN PREFERENCE
3460 TYPE2$="S"
3470 IF N>=S THEN TYPE2$="N"
3480 IXSTART=1
3490 IF N>=S THEN IXSTART=0
3500 SNSCORE=1
3510 FOR IX=IXSTART TO IXSTART+33
3520 IF ABS(S-N)=IX THEN GOTO 3550
3530 SNSCORE=SNSCORE+2
3540 NEXT IX
3550 PRINT TYPE2$, SNSCORE
3560 REM SCORE FOR TF PREFERENCE
3570 TYPE3$="T"
3580 IF F>=T THEN TYPE3$="F"
3590 IXSTART=1
3600 IF F>=T THEN IXSTART=0
3610 TFSCORE=1
3620 FOR IX=IXSTART TO IXSTART+33
3630 IF ABS(T-F)=IX THEN GOTO 3660
3640 TFSCORE=TFSCORE+2
3650 NEXT IX
3660 PRINT TYPE3$, TFSCORE
3670 REM SCORE FOR JP PREFERENCE
3680 TYPE4$="J"
3690 IF P>=J THEN TYPE4$="P"
3700 IXSTART=1
3710 IF P>=J THEN IXSTART=0
3720 JPSCORE=1
3730 FOR IX=IXSTART TO IXSTART+33
3740 IF ABS(J-P)=IX THEN GOTO 3770
3750 JPSCORE=JPSCORE+2
3760 NEXT IX
3770 PRINT TYPE4$,JPSCORE
3780 PRINT "Strike any key when printer is ready."
3790 AA$=INKEY$: IF AA$="" THEN GOTO 3790
3800 LPRINT "                    Special Report Form for Biology 110 Students"
3810 LPRINT "                         for the Myers-Briggs Type Indicator."
3820 LPRINT
3830 LPRINT "                                          General Biology"
3840 LPRINT "                                    The Ohio State University"
3850 LPRINT
3860 LPRINT
3870 LPRINT "Student Name", NNAME$
3880 LPRINT "Sex:  " SEXC$, "ID:  " SSN$
3890 LPRINT "Biology Section:  " BSEC$
3900  LPRINT QY$
3910 LPRINT
3920 LPRINT
3930 LPRINT "Your Type Came Out:"
3940 LPRINT
```

```
3950 LPRINT "-------------------------------------"
3960 LPRINT "|          |          |         |          |"
3970 LPRINT "|"+"    "+TYPE1$+"    |    "+TYPE2$+"    |    "+TYPE3$+"    |    "+TYP
E4$+"  |"
3980 LPRINT "|          |          |         |          |"
3990 LPRINT "-------------------------------------
4000 LPRINT
4010 LPRINT "Score:"
4020 LPRINT TYPE1$, EISCORE
4030 LPRINT TYPE2$, SNSCORE
4040 LPRINT TYPE3$, TFSCORE
4050 LPRINT TYPE4$, JPSCORE
4060 LPRINT
4070 LPRINT
4080 FOR IX=1 TO 8
4090 PAT$(IX)="|----|----|----|----|----|----|"
4100 NEXT IX
4110 IX=1
4120 IF EISCORE<=2 THEN EISCORE=3:  ' Set value to at least 3 for
4130 IF SNSCORE<=2 THEN SNSCORE=3:  ' upcoming graphics use with MID$
4140 IF TFSCORE<=2 THEN TFSCORE=3
4150 IF JPSCORE<=2 THEN JPSCORE=3
4160 IF TYPE1$="I" THEN IX=5
4170 IF IX=1 AND EISCORE>60 THEN EISCORE=60
4180 IF IX=1 THEN MID$(PAT$(IX), 31-INT((EISCORE-1)/2)+1,1) = "X" ELSE
             MID$(PAT$(IX), INT((EISCORE-1)/2)+1, 1)="X"
4190 IX=2
4200 IF TYPE2$="N" THEN IX=6
4210 IF IX=2 AND SNSCORE>60 THEN SNSCORE=60
4220 IF IX=2 THEN MID$(PAT$(IX), 30-INT((SNSCORE-1)/2)+1     ,1) = "X" ELSE
                   MID$(PAT$(IX), INT((SNSCORE-1)/2)+1,1)="X"
4230 IX=3
4240 IF TYPE3$="F" THEN IX=7
4250 IF IX=3 AND TFSCORE>60 THEN TFSCORE=60
4260 IF IX=3 THEN MID$(PAT$(IX), 30-INT((TFSCORE-1)/2)+1,     1)="X" ELSE
                   MID$(PAT$(IX), INT((TFSCORE-1)/2)+1,1)="X"
4270 IX=4
4280 IF TYPE4$="P" THEN IX=8
4290 IF IX=4 AND JPSCORE>60 THEN JPSCORE=60
4300 IF IX=4 THEN MID$(PAT$(IX), 30-INT((JPSCORE-1)/2)+1,      1)="X" ELSE
                    MID$(PAT$(IX), INT((JPSCORE-1)/2)+1,1)="X"
4310 LPRINT "                 P R E F E R E N C E   S T R E N G T H S"
4320 LPRINT
4330 LPRINT "E <---"+PAT$(1)+" "+PAT$(5)+"---> I"
4340 LPRINT
4350 LPRINT "S <---"+PAT$(2)+" "+PAT$(6)+"---> N"
4360 LPRINT
4370 LPRINT "T <---"+PAT$(3)+" "+PAT$(7)+"---> F"
4380 LPRINT
4390 LPRINT "J <---"+PAT$(4)+" "+PAT$(8)+"---> P"
4400 LPRINT "      6    5    4    3    2    1     0     1    2    3    4    5
6"
4410 LPRINT "      0    0    0    0    0    0           0    0    0    0    0
0"
4420 LPRINT
4430 LPRINT "Points:"
4440 LPRINT "E " E, "I " I
4450 LPRINT "S " S, "N " N
4460 LPRINT "T " T, "F " F
4470 LPRINT "J " J, "P " P
4480 FOR IX=1 TO 22
4490 LPRINT " "
4500 NEXT IX
4510 GOTO 240
```

GENERAL PURPOSE - NCS® - ANSWER SHEET
FOR USE WITH ALL NCS SENTRY · OPTICAL MARK READING SYSTEMS
SEE IMPORTANT MARKING INSTRUCTIONS ON SIDE 2

NAME (Last, First, MI)

[redacted]

SEX F ● M ○

GRADE OR EDUC

BIRTH DATE			IDENTIFICATION NUMBER	SPECIAL CODES
MO.	DAY	YR.	A B C D E F G H I J	K L M N O P
Sep ●	1 8	6 6	[redacted]	0 3 0

1 ①●③④⑤	11 ●②③④⑤	21 ●②③④⑤	31 ①●③④⑤	41 ①●③④⑤	51 ●②③④⑤	61 ①●③④⑤	71 ①●③④⑤	81 ①●③④⑤	91 ①●③④⑤
2 ①●③④⑤	12 ①●③④⑤	22 ①●③④⑤	32 ①●③④⑤	42 ●②③④⑤	52 ①●③④⑤	62 ①●③④⑤	72 ●②③④⑤	82 ①●③④⑤	92 ●②③④⑤
3 ●②③④⑤	13 ①②③④⑤	23 ①●③④⑤	33 ①●③④⑤	43 ①●③④⑤	53 ●②③④⑤	63 ●②③④⑤	73 ●②③④⑤	83 ①●③④⑤	93 ①②●④⑤
4 ①●③④⑤	14 ●②③④⑤	24 ①●③④⑤	34 ①●③④⑤	44 ①●③④⑤	54 ①●③④⑤	64 ●②③④⑤	74 ●②③④⑤	84 ①●③④⑤	94 ●②③④⑤
5 ①●③④⑤	15 ●②③④⑤	25 ①●③④⑤	35 ①●③④⑤	45 ①●③④⑤	55 ①●③④⑤	65 ●②③④⑤	75 ①●③④⑤	85 ①●③④⑤	95 ①●③④⑤
6 ①●③④⑤	16 ①●③④⑤	26 ●②③④⑤	36 ●②③④⑤	46 ●②③④⑤	56 ●②③④⑤	66 ●②③④⑤	76 ●②③④⑤	86 ①●③④⑤	96 ●②③④⑤
7 ●②③④⑤	17 ●②③④⑤	27 ①●③④⑤	37 ●②③④⑤	47 ●②③④⑤	57 ●②③④⑤	67 ①●③④⑤	77 ●②③④⑤	87 ①●③④⑤	97 ●②③④⑤
8 ●②③④⑤	18 ●②③④⑤	28 ●②③④⑤	38 ●②③④⑤	48 ①●③④⑤	58 ①●③④⑤	68 ●②③④⑤	78 ①●③④⑤	88 ①●③④⑤	98 ●②③④⑤
9 ①●③④⑤	19 ①●③④⑤	29 ①●③④⑤	39 ①●③④⑤	49 ●②③④⑤	59 ●②③④⑤	69 ①●③④⑤	79 ①●③④⑤	89 ●②③④⑤	99 ①●③④⑤
10 ①●③④⑤	20 ●②③④⑤	30 ①●③④⑤	40 ●②③④⑤	50 ①●③④⑤	60 ①●③④⑤	70 ①●③④⑤	80 ①●③④⑤	90 ①●③④⑤	100 ①●③④⑤

```
                Special Report Form for Biology 110 Students
                   for the Myers-Briggs Type Indicator.

                             General Biology
                       The Ohio State University

Student Name [redacted]
Sex:  MALE     ID: [redacted]
Biology Section:
Winter Quarter 1988

Your Type Came Out:

-----------------------------------
¦         ¦         ¦        ¦        ¦
¦    I    ¦    N    ¦   F    ¦   P    ¦
¦         ¦         ¦        ¦        ¦
-----------------------------------

Score:
I              9
N              13
F              7
P              27

                P R E F E R E N C E    S T R E N G T H S

E <---¦----¦----¦----¦----¦----¦----¦  ¦---X¦----¦----¦----¦----¦----¦---> I

S <---¦----¦----¦----¦----¦----¦----¦  ¦----¦X---¦----¦----¦----¦----¦---> N

T <---¦----¦----¦----¦----¦----¦----¦  ¦--X-¦----¦----¦----¦----¦----¦---> F

J <---¦----¦----¦----¦----¦----¦----¦  ¦----¦----¦--X-¦----¦----¦----¦---> P
      6    5    4    3    2    1    0    1    2    3    4    5  · 6
      0    0    0    0    0    0         0    0    0    0    0    0

Points:
E  11          I  15
S  9           N  15
T  9           F  12
J  7           P  20
```

APPENDIX J

COMPUTER-MANAGED INSTRUCTION STUDENT RECORD AND PERFORMANCE SCORE COMPUTATIONS

```
                    523001   CLASS 30,810        TOTAL TIME ON:    4:51    LAST DATE ON: 03/16/88     TODAY'S DATE: 03/16/88

                    1ST CHARACTERISTICS                     1ST TEST RESULTS     BEST CHARACTERISTICS                  BEST TEST RESULTS

UNIT TRY LK          A  B  C TOT POINTS       A  B  C TOT POINTS PCT  W%      A  B  C TOT POINTS          A  B  C TOT POINTS PCT  W%
---- --- --         -- -- -- --- -------     -- -- -- --- ------- --- ---    -- -- -- --- -------        -- -- -- --- ------- --- ---
 * A  2             12  8  5  25   34.0      10  7  2  19   24.5  76  72    12  8  5  25   34.0    A   10  8  4  22   30.0  88  88
 * B  1             12  8  5  25   34.0       9  6  4  19   26.0  76  76    12  8  5  25   34.0    B    9  6  4  19   26.0  76  76
 * C  2             12  8  5  25   34.0      10  4  3  17   22.0  68  65    12  8  5  25   34.0    C    7  6  4  17   24.0  68  71
 * E  1             12  8  5  25   34.0       9  8  4  21   29.0  84  85    12  8  5  25   34.0    E    9  8  4  21   29.0  84  85
 * F  1             12  8  5  25   34.0      10  5  5  20   27.5  80  81    12  8  5  25   34.0    F   10  5  5  20   27.5  80  81
 * I  1             12  8  5  25   34.0      12  5  5  22   29.5  88  87    12  8  5  25   34.0    I   12  5  5  22   29.5  88  87
 * G  1             12  8  5  25   34.0      10  7  5  22   30.5  88  90    12  8  5  25   34.0    G   10  7  5  22   30.5  88  90
 * J  1             12  8  5  25   34.0      10  7  5  22   30.5  88  90    12  8  5  25   34.0    J   10  7  5  22   30.5  88  90
 * D  1             12  8  5  25   34.0       8  7  5  20   28.5  80  84    12  8  5  25   34.0    D    8  7  5  20   28.5  80  84
   H  1             12  8  5  25   34.0       7  5  3  15   20.5  60  60    12  8  5  25   34.0    H    7  5  3  15   20.5  60  60
 * P  1             26 16  8  50   66.0      20 13  5  38   49.5  76  75    26 16  8  50   66.0    P   20 13  5  38   49.5  76  75
---- --- --         -- -- -- --- -------     -- -- -- --- ------- --- ---    -- -- -- --- -------        -- -- -- --- ------- --- ---
                                                                                      300   406.0                    238  325.5  78  80

UNIT                     OBJECTIVES NOT MASTERED ON BEST TEST                                                 WEIGHTING   FACTORS
                                                                                                              UNIT     A      B     C
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *                                           ----   ----   ----  ----
 * A  14  18  21                                                                                               A      1.0    1.5   2.0
 * B   1   2   3   7  12  19                                                                                   B      1.0    1.5   2.0
 * C   8  10  11  16  22  23  26                                                                               C      1.0    1.5   2.0
 * E   3   8   9                                                                                               E      1.0    1.5   2.0
 * F   3   6   8  12  13                                                                                       F      1.0    1.5   2.0
 * I   1  11  12                                                                                               I      1.0    1.5   2.0
 * G   3 [illegible] 18                                                                                        G      1.0    1.5   2.0
 * J   2   6  14                                                                                               J      1.0    1.5   2.0
 * D   7   5   6  15  20                                                                                       D      1.0    1.5   2.0
 * H   1   5   8   9  10  12  17  18  22  32                                                                   H      1.0    1.5   2.0
 * P   3   4   5   6   7   8   9  10                                                                           P      1.0    1.5   2.0

 Maximum Points                      :  406.0
 Student's Test Points               :  325.5
 Student's Lab Work Points           :    1.0
 Student's LSP/MAII Points           :    6.0
 Student's Bonus Points              :    4       (A=2,B=0,C=0,D=0,E=0,F=0,G=0,H=0,I=0,J=2)
 Student's Total Points              :  336.5
 Student's Total Weighted Score:        83%
 -----------------------------------------

 LETTER GRADE: B
```

STUDENT RECORD
Computer-Managed Instruction

```
                              530200   CLASS  2.810        TOTAL TIME ON:   16:02    LAST DATE ON:                   TODAY'S DATE:

                        1ST CHARACTERISTICS                1ST TEST RESULTS       BEST CHARACTERISTICS                     BEST TEST RESULTS

UNIT TRY LK               A  B  C TOT POINTS          A  B  C TOT POINTS PCT  WS      A  B  C TOT POINTS            A  B  C TOT POINTS PCT  WS
---- --- --              -- -- -- --- -------        -- -- -- --- ------- --- ---     -- -- -- --- -------           -- -- -- --- ------- --- ---
 * A   3                 12  8  5  25   34.0          8  5  4  17   23.5  68  69     12  8  5  25   34.0        A   11  6  5  22   30.0  88  88
 * B   2                 12  8  5  25   34.0          9  5  4  18   24.5  72  72     12  8  5  25   34.0        B   12  4  5  21   28.0  84  82
 * C   1                 12  8  5  25   34.0         11  6  4  21   28.0  84  82     12  8  5  25   34.0        C   11  6  4  21   28.0  84  82
   D   1                 12  8  5  25   34.0          8  4  3  15   20.0  60  59     12  8  5  25   34.0        D    8  4  3  15   20.0  60  59
   E   1                 12  8  5  25   34.0         11  3  3  17   21.5  68  63     12  8  5  25   34.0        E   11  3  3  17   21.5  68  63
   G   1                 12  8  5  25   34.0          9  2  3  14   18.0  56  53     12  8  5  25   34.0        G    9  2  3  14   18.0  56  53
 * H   3                 12  8  5  25   34.0          4  8  4  16   24.0  64  71     12  8  5  25   34.0        H    8  8  5  21   30.0  84  88
 * I   2                 12  8  5  25   34.0          5  6  2  13   18.0  52  53     12  8  5  25   34.0        I   10  [illegible]  21   [illegible]  84  84
 * J   1                 12  8  5  25   34.0         11  5  5  21   28.5  84  84     12  8  5  25   34.0        J   11  5  5  21   28.5  84  84
   F   2                 12  8  5  25   34.0          6  2  3  11   15.0  44  44     12  8  5  25   34.0        F    6  2  3  11   15.0  44  44
 * P   3 **              26 16  8  50   66.0         17 11  7  35   47.5  70  72     26 16  8  50   66.0        P   17 11  7  36   47.5  70  73
---- --- --              -- -- -- --- -------        -- -- -- --- ------- --- ---     -- -- -- --- -------           -- -- -- --- ------- --- ---
                                                                                               300  406.0                      318  295.0  73  75
```

Total 268.5 = 66%
(PS1)

```
UNIT                  OBJECTIVES NOT MASTERED ON BEST TEST                                                      WEIGHTING   FACTORS
                                                                                                                UNIT     A     B     C
----------------------------------------------------------------------------------------------                  ----  ----  ----  ----
 * A   9  11  18                                                                                                A     1.0   1.5   2.0
 * B   2  16  17  18                                                                                            B     1.0   1.5   2.0
 * C   3  11  20  29                                                                                            C     1.0   1.5   2.0
   D   2   3   4   5   6   7  12  13  21                                                                        D     1.0   1.5   2.0
   E   2   7   8   9  10  11  13                                                                                E     1.0   1.5   2.0
   G   4  13  17  18  19  20  24  25  26  30                                                                    G     1.0   1.5   2.0
 * H   6   8  12  17                                                                                            H     1.0   1.5   2.0
 * I   7   8  11  14                                                                                            I     1.0   1.5   2.0
 * J   3   4   5  14                                                                                            J     1.0   1.5   2.0
   F   1   2   3   4   5   6   8  10  11  12  13                                                                F     1.0   1.5   2.0
 * P   3   4   5   6   7   8  10                                                                                P     1.0   1.5   2.0

Maximum Points                   : 406.0
Student's Test Points            : 295.0   73% *PS2)
Student's Lab Work Points        :   1.0
Student's LSP/MBII Points        :   9.0
Student's Bonus Points           :   3        (A=1,B=0,C=0,D=0,E=0,F=0,G=0,H=0,I=0,J=2)
Student's Total Points           : 308.0
Student's Total Weighted Score:    76%
-----------------------------------------

LETTER GRADE: C
```

Instructions to compute point totals (percent)

1. Add 1st test results in points. Example: 268.5

2. Divide this figure by maximum points available. Example: $\frac{268.5}{406} = 66\%$

3. Divide student's test points (same as Best Test Results) by maximum points. Example: $\frac{295}{406} = 73\%$

4. Round percent to nearest whole number.

APPENDIX K

LISTING OF COLLEGE MAJORS AND GRADE POINT AVERAGES IN BIOLOGY 110

MAJOR	FREQUENCY	PERCENT
	60	.
ACCTING	26	2.9
ACT SCI	2	0.2
AG M&SYS	2	0.2
AGR COMM	5	0.6
AGR ECON	16	1.8
AGR EDUC	7	0.8
AGR-UND	3	0.3
AGRONOMY	6	0.7
ANIML SC	12	1.3
ANTHROP	1	0.1
ARCH	2	0.2
ARCH-UND	4	0.4
ART EDUC	4	0.4
ASC-UND	21	2.3
AVIA-ASC	4	0.4
AVIATION	1	0.1
BI SC ED	1	0.1
BIO-UND	4	0.4
BIOCHEM	4	0.4
BIOLOGY	10	1.1
BOTANY	1	0.1
BRODCST C	1	0.1
BUS EDU	1	0.1
BUS-UND	58	6.5
CERAM EN	1	0.1
CHEM	6	0.7
COMMUNIC	8	0.9
CONT EDU	26	2.9
CNTR/INF	1	0.1
CRIMINOL	3	0.3
DAIRY SC	1	0.1
DANCE	2	0.2
DHY EDU	1	0.1
ECON	1	0.1
ECON-BUS	1	0.1
EMNTL RF	3	0.3
EDUC	1	0.1
EDUC-UND	72	8.0
ELEC ENG	2	0.2
ELEM EDU	18	2.0
ENG-UND	5	0.6
ENGL EDU	4	0.4
ENGLISH	4	0.4
FINANCE	4	0.4
FM RES M	3	0.3
FM&HU DV	9	1.0
FRENCH	1	0.1
FRST MGT	1	0.1
GEN F A	1	0.1
GEOLOGY	2	0.2
HEC-UND	27	3.0
HISTORY	3	0.3
HLTH EDU	1	0.1
HORT	2	0.2
HOSP MGT	19	2.1
HUMAN NTR	1	0.1
HUMN RES	3	0.3
IND TECH	1	0.1
INFO SYS	4	0.4
INS&RISK	1	0.1
INT DSGN	1	0.1
INT STDS	3	0.3
INTL BUS	4	0.4
JOURNAL	9	1.0
LARCH	1	0.1
MARKETING	9	1.0
MATH	4	0.4
MATH EDU	4	0.4
MATH SCI	1	0.1
MCD BIO	1	0.1
MECH ENG	1	0.1
MICROBIOL	4	0.4
MOL GEN	6	0.7
MUS-UND	1	0.1
MUSEDART	1	0.1
MUSIC ED	4	0.4
NRE-UND	1	0.1
NURSING	1	0.1
ORCH INS	2	0.2
P&C ART	2	0.2
PARK ADM	1	0.1
PHARMACY	1	0.1
PHYS ED	9	1.0
POLIT SC	6	0.7
PRE-AAE	3	0.3
PRE-AMP	32	3.6
PRE-DEN	3	0.3
PRE-DHY	8	0.9
PRE-EE	3	0.3
PRE-ISE	1	0.1
PRE-MCOM	1	0.1
PRE-MECE	2	0.2
PRE-MED	11	1.2
PRE-MILL	1	0.1

MAJOR	FREQUENCY	PERCENT
PRE-MTEC	4	0.4
PRE-NRAN	1	0.1
PRE-NUR	27	3.0
PRE-OPT	1	0.1
PRE-PHR	35	3.9
PRE-PT	37	4.1
PRE-RADT	11	1.2
PRE-RESP	1	0.1
PRE-SWK	9	1.0
PRE WELE	1	0.1
PRE-OT	7	0.8
PRECISAS	2	0.2
PRECISEN	2	0.2
PROD DSN	1	0.1
PROD MGT	2	0.2
PSYCH	13	1.5
RCERT EL	1	0.1
RE&UR AN	1	0.1
REC EDUC	3	0.3
ROMLANG	1	0.1
RSRC MGT	1	0.1
SLAVIC	1	0.1
SO ST ED	2	0.2
SOCIOL	2	0.2
TXTL&CLO	2	0.2
UNKNOWN	142	15.8
VSUL DSN	3	0.3
WILD MGT	1	0.1
ZOOLOGY	1	0.1

GPA	FREQUENCY	PERCENT
	60	.
0.00	93	10.4
0.23	1	0.1
0.50	2	0.2
0.54	1	0.1
0.57	1	0.1
0.64	1	0.1
0.67	3	0.3
0.69	1	0.1
0.77	2	0.2
0.85	2	0.2
0.88	1	0.1
0.90	2	0.2
0.92	1	0.1
0.99	1	0.1
1.00	4	0.4
1.01	1	0.1
1.06	1	0.1
1.10	1	0.1
1.12	1	0.1
1.13	1	0.1
1.14	2	0.2
1.15	2	0.2
1.17	1	0.1
1.19	1	0.1
1.20	2	0.2
1.23	3	0.3
1.29	1	0.1
1.32	2	0.2
1.33	2	0.2
1.36	1	0.1
1.39	1	0.1
1.43	1	0.1
1.44	1	0.1
1.46	2	0.2
1.47	1	0.1
1.49	2	0.2
1.50	2	0.2
1.51	2	0.2
1.52	4	0.4
1.53	5	0.6
1.54	3	0.3
1.55	3	0.3
1.57	3	0.3
1.58	2	0.2
1.59	2	0.2
1.60	1	0.1
1.61	2	0.2
1.62	3	0.3
1.63	6	0.7
1.64	2	0.2
1.65	1	0.1
1.67	5	0.6
1.68	3	0.3
1.69	2	0.2
1.71	4	0.4
1.72	3	0.3
1.73	1	0.1
1.74	1	0.1
1.75	2	0.2
1.76	5	0.6
1.77	9	1.0
1.78	2	0.2
1.79	2	0.2
1.80	3	0.3
1.81	4	0.4
1.82	2	0.2
1.83	1	0.1
1.84	3	0.3
1.85	2	0.2
1.86	1	0.1
1.87	4	0.4
1.88	2	0.2
1.89	5	0.6
1.90	8	0.9
1.91	1	0.1
1.92	1	0.1
1.93	6	0.7
1.94	4	0.4
1.95	4	0.4
1.96	5	0.6
1.97	3	0.3
1.98	4	0.4
1.99	2	0.2
2.00	10	1.1
2.01	4	0.4
2.02	2	0.2
2.03	5	0.6
2.04	3	0.3
2.05	3	0.3
2.06	6	0.7
2.07	3	0.3
2.08	7	0.8
2.09	4	0.4
2.10	11	1.2
2.11	2	0.2
2.12	5	0.6
2.13	8	0.9

GPA	FREQUENCY	PERCENT
2.14	5	0.6
2.15	5	0.6
2.16	7	0.8
2.17	7	0.8
2.18	1	0.1
2.19	2	0.2
2.20	4	0.4
2.21	4	0.4
2.22	6	0.7
2.23	13	1.5
2.24	2	0.2
2.25	4	0.4
2.26	1	0.1
2.27	1	0.1
2.28	4	0.4
2.29	2	0.2
2.30	2	0.2
2.31	4	0.4
2.32	4	0.4
2.33	6	0.7
2.34	5	0.6
2.35	7	0.8
2.36	4	0.4
2.37	5	0.6
2.38	1	0.1
2.39	5	0.6
2.40	4	0.4
2.41	4	0.4
2.42	1	0.1
2.43	11	1.2
2.44	6	0.7
2.46	3	0.3
2.47	6	0.7
2.48	3	0.3
2.49	4	0.4
2.50	8	0.9
2.51	2	0.2
2.52	3	0.3
2.53	2	0.2
2.54	5	0.6
2.55	2	0.2
2.56	3	0.3
2.57	4	0.4
2.58	5	0.6
2.59	3	0.3
2.60	1	0.1
2.61	6	0.7
2.62	3	0.3
2.63	5	0.6
2.64	4	0.4
2.65	3	0.2
2.66	6	0.7
2.67	15	1.7
2.68	5	0.6
2.69	2	0.2
2.70	5	0.6
2.71	1	0.1
2.72	4	0.4
2.73	1	0.1
2.74	2	0.2
2.75	5	0.6
2.76	3	0.3
2.77	11	1.2
2.78	1	0.1
2.79	2	0.2
2.80	4	0.4
2.81	4	0.4
2.82	3	0.3
2.83	4	0.4
2.84	2	0.2
2.85	3	0.3
2.86	3	0.3
2.87	4	0.4
2.88	5	0.6
2.89	5	0.6
2.90	8	0.8
2.91	3	0.3
2.92	2	0.2
2.93	3	0.3
2.94	3	0.3
2.95	5	0.6
2.96	2	0.2
2.97	3	0.3
2.98	1	0.1
2.99	2	0.2
3.00	13	1.5
3.01	1	0.1
3.03	3	0.3
3.05	3	0.3
3.06	1	0.1
3.07	2	0.2
3.08	3	0.3
3.09	1	0.1
3.10	10	1.1
3.11	3	0.3
3.12	1	0.1
3.13	5	0.6
3.14	1	0.1
3.15	2	0.2
3.16	3	0.3
3.17	3	0.3
3.18	3	0.3

GPA	FREQUENCY	PERCENT
3.19	2	0.2
3.20	10	1.1
3.21	1	0.1
3.23	2	0.2
3.24	1	0.1
3.25	1	0.1
3.26	1	0.1
3.27	1	0.1
3.28	1	0.1
3.29	2	0.2
3.30	2	0.2
3.31	4	0.4
3.33	4	0.4
3.35	3	0.3
3.36	2	0.2
3.38	3	0.3
3.39	3	0.3
3.41	3	0.3
3.43	4	0.4
3.44	3	0.3
3.45	2	0.2
3.46	1	0.1
3.47	3	0.3
3.48	1	0.1
3.49	1	0.1
3.50	1	0.1
3.51	1	0.1
3.52	2	0.2
3.54	3	0.3
3.55	2	0.2
3.56	2	0.2
3.57	7	0.8
3.58	1	0.1
3.61	3	0.2
3.62	3	0.2
3.63	1	0.1
3.64	2	0.2
3.65	1	0.1
3.66	2	0.2
3.67	6	0.7
3.70	2	0.2
3.76	1	0.1
3.77	3	0.3
3.78	1	0.1
3.79	1	0.1
3.80	2	0.2
3.81	1	0.1
3.82	1	0.1
3.83	3	0.3
3.85	2	0.2
3.86	1	0.1
3.90	1	0.1
3.91	2	0.2
3.94	1	0.1
3.98	1	0.1
4.00	10	1.1

APPENDIX L

RATING FORM FOR COGNITIVE PROCESS ANALYSIS AND SAMPLE QUESTION

Rating Form for Cognitive Process Analysis

Use check mark (✓) to rate each question according to the degree to which each cognitive process is required.

Example attached.

COGNITIVE PROCESS(es) REQUIRED TO ANSWER THIS QUESTION

Question ID h18c 13

ANALYSIS	none		✓ some		a lot
SPATIAL	none		some	✓	a lot
DISCRIMINATION	none		✓ some		a lot
CATEGORIZATION	✓ none		some		a lot
SEQUENTIAL PROCESSING	✓ none		some		a lot
MEMORY	none		some		✓ a lot

Rater's Name ____________________

```
     ****************************************   ************************************************************************

✓ 13 QUESTION                     1/06/87 *      Refer to Visual H-4  The area labeled  9 is the ________                    1
     SCALE                                      1...*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

     SPECIAL FEATURES                           NONE

     OPTIONS                                      CLEAR   INFO   DIV   ARROW STOP=5   ID   SHOW   SCORE   INPUT
                                                NOCALC   ERASE   MICRO   MAIN  TOP-LT R,C=01,01 BOT-RT R,C=01,79
                                                TRIES: 1
     GROUP  1 - CORRECT                    1    epididymis:
              OPTIONS                            COUNT

     ****************************************   ************************************************************************

  14 QUESTION                     1/08/87 *      Refer to Visual H-4   9 is the site for the production of the             1
                                          *      hormone _______________________                                               2
     SCALE                                      1 . * . 1 . * . 2 . * . 3 . * . 4 . * . 5 . * . 6 . * . 7 . * . 8

     SPECIAL FEATURES                           NONE

     OPTIONS                                      CLEAR   INFO   DIV   ARROW STOP=5   ID   SHOW   SCORE   INPUT
                                                NOCALC   ERASE   MICRO   MAIN  TOP-LT R,C=01,01 BOT-RT R,C=02,79
                                                TRIES: 1
     GROUP  1 - CORRECT                    1    testosterone:
              OPTIONS                            COUNT

     ****************************************   ************************************************************************

  15 QUESTION                     1/06/87 *      Refer to Visual H-4  The ______ is the gland labeled 13                    1
     SCALE                                      1...*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

     SPECIAL FEATURES                           NONE

     OPTIONS                                      CLEAR   INFO   DIV   ARROW STOP=5   ID   SHOW   SCORE   INPUT
                                                NOCALC   ERASE   MICRO   MAIN  TOP-LT R,C=01,01 BOT-RT R,C=01,79
                                                TRIES: 1
     GROUP  1 - CORRECT                    2    seminal vesicle:
                                           2    seminal vesicles:
              OPTIONS                            COUNT
```

BEST COPY AVAILABLE

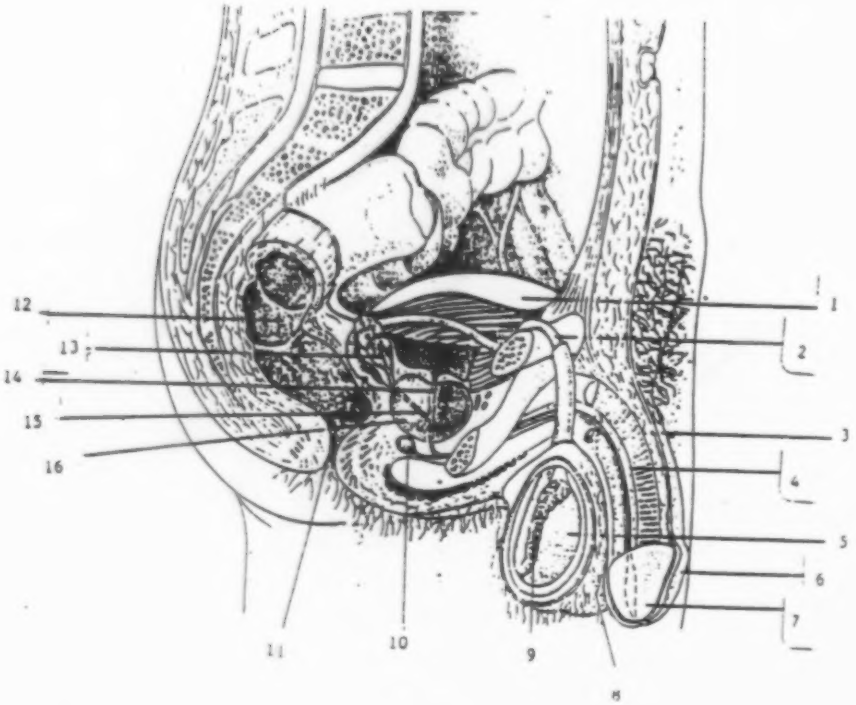
12
13
14
15
16
11
10
9
8
1
2
3
4
5
6
7

Figure 5. Visual H-4

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APPENDIX M

CHARACTERISTICS FREQUENTLY ASSOCIATED WITH EACH MBTI TYPE

Characteristics frequently associated with each type

	Sensing Types		Intuitive Types	
Introverts	**ISTJ** Serious, quiet, earn success by concentration and thoroughness. Practical, orderly, matter-of-fact, logical, realistic, and dependable. See to it that everything is well organized. Take responsibility. Make up their own minds as to what should be accomplished and work toward it steadily, regardless of protests or distractions.	**ISFJ** Quiet, friendly, responsible, and conscientious. Work devotedly to meet their obligations. Lend stability to any project or group. Thorough, painstaking, accurate. Their interests are usually not technical. Can be patient with necessary details. Loyal, considerate, perceptive, concerned with how other people feel.	**INFJ** Succeed by perseverance, originality, and desire to do whatever is needed or wanted. Put their best efforts into their work. Quietly forceful, conscientious, concerned for others. Respected for their firm principles. Likely to be honored and followed for their clear convictions as to how best to serve the common good.	**INTJ** Usually have original minds and great drive for their own ideas and purposes. In fields that appeal to them, they have a fine power to organize a job and carry it through with or without help. Skeptical, critical, independent, determined, sometimes stubborn. Must learn to yield less important points in order to win the most important.
	ISTP Cool onlookers—quiet, reserved, observing and analyzing life with detached curiosity and unexpected flashes of original humor. Usually interested in cause and effect, how and why mechanical things work, and in organizing facts using logical principles.	**ISFP** Retiring, quietly friendly, sensitive, kind, modest about their abilities. Shun disagreements, do not force their opinions or values on others. Usually do not care to lead but are often loyal followers. Often relaxed about getting things done, because they enjoy the present moment and do not want to spoil it by undue haste or exertion.	**INFP** Full of enthusiasms and loyalties, but seldom talk of these until they know you well. Care about learning, ideas, language, and independent projects of their own. Tend to undertake too much, then somehow get it done. Friendly, but often too absorbed in what they are doing to be sociable. Little concerned with possessions or physical surroundings.	**INTP** Quiet and reserved. Especially enjoy theoretical or scientific pursuits. Like solving problems with logic and analysis. Usually interested mainly in ideas, with little liking for parties or small talk. Tend to have sharply defined interests. Need careers where some strong interest can be used and useful.
Extraverts	**ESTP** Good at on-the-spot problem solving. Do not worry, enjoy whatever comes along. Tend to like mechanical things and sports, with friends on the side. Adaptable, tolerant, generally conservative in values. Dislike long explanations. Are best with real things that can be worked, handled, taken apart, or put together.	**ESFP** Outgoing, easygoing, accepting, friendly, enjoy everything and make things more fun for others by their enjoyment. Like sports and making things happen. Know what's going on and join in eagerly. Find remembering facts easier than mastering theories. Are best in situations that need sound common sense and practical ability with people as well as with things.	**ENFP** Warmly enthusiastic, high-spirited, ingenious, imaginative. Able to do almost anything that interests them. Quick with a solution for any difficulty and ready to help anyone with a problem. Often rely on their ability to improvise instead of preparing in advance. Can usually find compelling reasons for whatever they want.	**ENTP** Quick, ingenious, good at many things. Stimulating company, alert and outspoken. May argue for fun on either side of a question. Resourceful in solving new and challenging problems, but may neglect routine assignments. Apt to turn to one new interest after another. Skillful in finding logical reasons for what they want.
	ESTJ Practical, realistic, matter-of-fact, with a natural head for business or mechanics. Not interested in subjects they see no use for, but can apply themselves when necessary. Like to organize and run activities. May make good administrators, especially if they remember to consider others' feelings and points of view.	**ESFJ** Warm-hearted, talkative, popular, conscientious, born cooperators, active committee members. Need harmony and may be good at creating it. Always doing something nice for someone. Work best with encouragement and praise. Main interest is in things that directly and visibly affect people's lives.	**ENFJ** Responsive and responsible. Generally feel real concern for what others think or want, and try to handle things with due regard for the other person's feelings. Can present a proposal or lead a group discussion with ease and tact. Sociable, popular, sympathetic. Responsive to praise and criticism.	**ENTJ** Hearty, frank, decisive, leaders in activities. Usually good in anything that requires reasoning and intelligent talk, such as public speaking. Are usually well informed and enjoy adding to their fund of knowledge. May sometimes appear more positive and confident than their experience in an area warrants.

APPENDIX N

FACTOR ANALYSIS

SPATIAL ITEMS

TABLE 44

THE OUTCOME OF 19 FACTOR ANALYSIS: LOADINGS () AND CUMULATIVE VARIANCES []

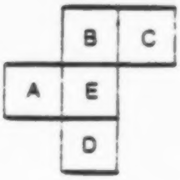
[.11]	[.20]	[.28]	[.35]	[.41]	[.48]	[.53]
Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
v62(.66)	v61(.54)	v65(-.62)	v63(.74)	v64(.79)	v71(.57)	v68(.47)
v66(.62)	v67(.82)	v70(.71)	v88(.68)	v73(.68)	v78(.74)	v74(.55)
v72(-.31)	v69(.76)	v83(.73)	v96(.82)	v82(.80)	v81(.69)	v84(.69)
v77(-.69)	v80(.70)	v90(.51)		v102(.44)	v101(.80)	v91(.69)
v89(-.67)	v98(.74)	v99(-.73)				
v93(-.72)						
v106(-.50)						
Study Time	Lighting	Grouping	Temp.	Manipulative	Sound	Persistence

[.59]	[.63]	[.67]	[.70]	[.74]	[.76]	[.79]
Factor8	Factor9	Factor10	Factor11	Factor12	Factor13	Factor14
v25(.57)	v76(.58)	v109(.17)	v79(.55)	v94(.56)	v75(.53)	v1(.32)
v26(.27)	v103(.64)	v110(.20)	v87(.56)	v100(.58)	v92(.43)	v2(.60)
v27(.46)	v108(.64)	v112(.26)	v97(.60)	v104(.63)	v95(.55)	v3(.37)
v28(.68)		v114(.34)	v105(.48)		v107(.38)	v4(.43)
v29(.57)		v116(.33)				v5(.39)
		v118(.52)				v6(.44)
		v120(.46)				
		v121(.26)				
		v123(.33)				
		v124(.54)				
		v126(.42)				
Analytic	Mobility	Memory	Posture	Study Tm. Late Aft.	Verbal Risk	Sequent. Process.

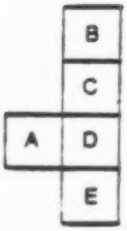
[.82]	[.84]	[.87]	[.89]	[.91]
Factor15	Factor16	Factor17	Factor18	Factor19
v7(.40)	v111(.38)	v30(.37)	v31(.40)	v89(.40)
v8(.58)	v113(.38)	v33(.36)	v35(.40)	v93(.36)
v9(.49)	v117(.43)	v34(.38)	v39(.36)	
v10(.39)	v122(.38)		v36(.23)	
v11(.55)	v125(.43)		v37(.28)	
			v40(.30)	
Discrimination	Memory	Verbal-Spatial		Study Tm. Late Morn.

These squares will fold into a box which is open at the top. Which letter would mark the BOTTOM of the box?

36.

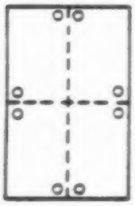


37.

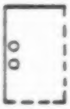


This sheet of paper has holes punched in it. How will the paper look after it is folded on the dotted lines?

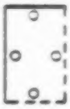
38.



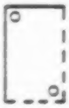
A



B



C



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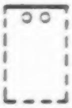
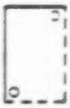
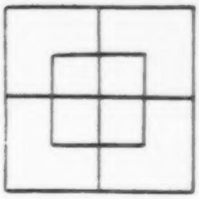


E



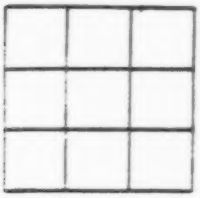
How many squares can you find in the shapes below?

39.



A. 6 B. 8 C. 10 D. 12 E. 14

40.



A. 9 B. 10 C. 12 D. 13 E. 14

In the questions on the following page, you will read some words that you know well. As you read each word, notice the *first thing* you think of:

A. Do you see a PICTURE of something?
B. Do you hear the SOUND of the word?
C. Do you have a FEELING about the word?

Example: Suppose you read the word "hold." You might see one football player holding another. In this case, you would mark A for PICTURE. Remember that it does not matter what you see, only that the word brings some PICTURE to your mind. Or you might not see a picture, but understand the meaning of the word from the SOUND alone. In that case, you would mark B for SOUND. Or you might have a FEELING about the word, as if you were holding someone, or feeling happiness or fear. In that case, you would mark C for FEELING.

Do not puzzle over your choices. Mark the first choice that comes to your mind for each word.

—CHECK YOUR ANSWER SHEET—YOU SHOULD NOW BE AT QUESTION 41—

LIST OF REFERENCES

American Association for the Advancement of Science (AAAS). (1989). Science for all Americans summary. Washington, DC: AAAS.

Andrews, D., & Goodson, L. (1980). A comparative analysis of models of instructional design. Journal of Instructional Development, 3(4), 2-16.

Bloch, E. (1987). Meeting our need for science and engineering talent: The precollege connection. Journal of College Science Teaching, 17(2), 100-101.

Bloom, B.S. (1976). Human characteristics and school learning. New York: McGraw-Hill.

Bloom, B., Engelhart, M., Furst, E., Hill, W., & Krathwohl, D. (1956). Taxonomy of Educational Objectives: Cognitive Domain.

Blystone, R. (1987). College introductory biology textbooks. American Biology Teacher, 49(7): 418-425.

Bozeman, W. (1978). An investigation of psychological typology as an intervening variable in the implementation of a computer managed instruction system, Dissertation Abstracts International, 39-A, 3639-A, 2640-A. In Sharma. (1987). Learners' cognitive styles and psychological types as intervening variables influencing performance in computer science courses. Journal of Educational Technology Systems, 15(4), 391-399.

Campbell, D. E. (1986). Adult learners' changes and adaptations of learning methods, techniques and devices by psychological type (Doctoral dissertation, Ohio State University, 1986). Dissertation Abstracts International, 47, 10A, 3700.

Carlson, E. (1981). Biology for non-majors. In A. W. Chickering and Associates (Eds.), The Modern American College (pp. 440-452). Washington: Jossey-Bass.

Carrier, C., & Jonassen, D. (1988). Adapting courseware to accommodate individual differences. In David H. Jonassen (Ed.), Instructional designs for microcomputer courseware (pp. 203-226). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Champagne, A. (1988, September). Research matters . . . to the science teacher: Definition and assessment of the higher-order cognitive skills. NARST News, 29(3).

Champagne, A., & Hornig, L. (Eds.). (1987). Students and science learning. Washington: American Association for the Advancement of Science.

Charlton, Ronald E.(1980). Cognitive style considerations for the improvement of biology education. American Biology Teacher, 42(4), 244-247.

Claxton, O., & Murrell P. (1987). Learning styles: Implications for improving educational practices. Clearinghouse on Higher Education. Washington: The George Washington University. (ASHE-ERIC Higher Education Report No. 4).

Coldeway, D., & Coldeway A. (1987). Extending behavioral instructional methods through the use of instructional systems design technology. Paper presented at International Society for Individualized Instruction Annual Conference. Fort Collings, CO.

Consulting Psychologists Press. (1986). Atlas of Type Tables. Palo Alto, CA: Consulting Psychologists Press.

Cronin, L., Charron, E., & Espinet, M. (1987). The relative difficulty of teaching science in elementary and secondary school: A response. Journal of Research in Science Teaching, 24(2), 183-186.

Curry, L. (1983). An organization of learning styles theory and constructs. Paper presented at the Annual Meeting of the American Educational Research Association. ERIC Document No. ED 235 185.

Daon, Y. (1985/1986). An analysis of relationships between individual learning styles and student performance in a programming course. Dissertation Abstracts International. (46, 7A, 1822).

Davis, P., & Solomon, E. (1986). The World of Biology. New York: Saunders College Publishing Company.

Dean, D. (1978). The nonmajor: A challenge and a responsibility. American Biology Teacher, 40(9), 564-5.

diSessa, A., & Ploger, D. (1987). Cognition and science education. In A. Champagne and L. Hornig (Eds.), Students and School Learning (pp.15-37) Washington: American Association for the Advancement of Science.

Dodge, R. (1987). Getting started with a needs assessment: A nuts and bolts approach for putting one together. Performance and Instruction, pp. 16-20.

Douglass, C. (1979). Making biology easier to understand. American Biology Teacher, 41(5), 277-281, 298-299.

Dunn, R. (1984). Learning style: State of the science. In Henson, K. (Ed.), Matching Teaching and Learning Styles. Columbus, Ohio: The Ohio State University.

Dunn, R.(1980). Learning: A matter of style. Educational Leadership, 37(4), 360-361.

Dykstra, D. (1987). Science education in elementary school: Some observations. Journal of Research in Science Teaching, 24(2), 179-182.

Eberhard, C. (1985). General Biology Laboratory Manual. New York: Saunders College Publishing Company.

Fensham, P.J. (1987). Science for all. Educational Leadership, 44, 18-23.

Ferrell, B. (1988). Using the NASSP Learning Style Profile. Restons, VA: National Association of Secondary School Principals.

Finley, F. (1983). Science Processes. Journal of Research in Science Teaching, 20(2),47-54.

Flannery, M. C. (1987). Beginning again. American Biology Teacher, 48(6), 369-371.

Gabel, L. (1976). The development of a model to determine perceptions of scientific literacy. Unpublished manuscript, The Ohio State University, Columbus.

Gable, K. (1986). Post-secondary health occupations students' preferences for accessing, processing and judging information: An analysis using the Myers-Briggs Type Indicator. Dissertation Abstracts International, 47, 2A, 431.

Gagne, R.M., & Briggs, L.J. (1979). Principles of instructional design. New York: Holt, Rinehard & Winston.

Gardner, M. (1985). Good, but not perfect. Journal of College Science Teaching, 25(1), 7-8.

Gay, L. (1981). Educational research. Competencies for analysis and application. Columbus: Charles E. Merrill, Publishing Co.

GE's Walter Robb: Reviving corporate research in the U.S. (1989, January 23). The Scientist. p. 9.

GWBasic manual. Version 1.4. National Cash Register. No Date.

Hall, K.A. (1983). Content structuring and question asking for computer-based education. Journal of computer-based in- struction, 10(1&2), 1-7.

Harms, N.,& Yager, R., Eds. (1981). What research says to the science teacher,3. National Science Teachers Association, Washington, D.C.

Henson, K. Ed. (1984). Matching teaching and learning styles in Theory into Practice. Columbus: The Ohio State University.

Hoffman, J., & Waters, K. (March, 1982). Some effects of student personality on success with computer-assisted instruction. Educational Technology, pp. 2-21. In S. Sharma (1987). Learners' cognitive styles and psychological types as intervening variables influencing performance in computer science courses. Journal of Educational Technology Systems, 15(4), 391-399.

Hueftle, S.M., Rakow, S.J.,& Welch, W.W. (1983). Images of science: a summary of results from the 1981-1982 NAEP. Minnesta Research and Evaluation Center. Minneapolis: University of Minnesota.

Hurd, P. (1978). The golden age of biological education, 1960-1975. Biological sciences curriculum study (BSCS) Biology Teachers Handbook (3rd ed.). New York: John Wiley & Sons, Inc.

Hurd, P. (1981). Biology education. What research says to the science teacher. Vol.3. Washington: National Science Teachers Association.

Hurd, P. (1986). Perspectives for the reform of science education. Phi Delta Kappan, 67(5), 353-8.

James, R.K., & Smith, S. (1985). Alienation of students from science in grades 4-12. Science Education, 69(1), 39-45.

Jensen, G. (1987). Learning styles. In J. A. Provost & S. Anchors (Eds.), Application of the MBTI in Higher Education (pp. 181-206). Palo Alto, CA: Consulting Psychologists Press.

Johnson, R., & Peeples, E. (1987). The role of scientific understanding in college. American Biology Teacher, 49 (2), 93-98.

Jung, C. G. (1921). Psychological Types (English translation, H.G. Baynes, 1923). Princeton: Princeton University Press.

Kalsbeek, D. (1987). Campus retention: The MBTI in institutional self studies. In J.A. Provost & S. Anchors (Eds.), Application of the MBTI in higher education. (pp. 31-63). Palo Alto, CA: Consulting Psychologists Press.

Kearsley, G. (1984). Training and technology. Reading, Mass: Addison-Wesley.

Keefe, J. (1988). Profiling and using learning style. Reston, VA: National Association of Secondary School Principals.

Keefe, J., & Monk, J. (1986). Learning style profile examiner's manual. Reston, VA: National Association of Secondary School Principals.

Keefe, J., Monk, J., Letteri, C., Languis, M., & Dunn, R. (1986). Learning Style Profile. National Association of Secondary School Principals. Reston, VA.

Kennedy, J. (1988). Exploratory Data Analysis class notes. Educational Theory and PRactice 925K60. The Ohio State University.

Kern, G., & Matta, K. (1988). The influence of personality on self-paced instruction. Journal of Computer-Based Instruction, 15(3), 104-108.

Kim, J., & Mueller, C. (1978). Factor analysis statistical methods and practial issues. Beverly Hills: SAGE Publications.

Kuerbis, P. (March, 1988). Research matters . . . to the science teacher: Learning styles and science teaching. NARST News, 3(1).

Lawrence, G. (1984). A synthesis of learning style research involving the MBTI. Journal of Psychological Type, 8, 2-15.

Lawrence, G. (1987). People types and tiger stripes (2nd ed.). Gainesville: Center for Applications of Psychological Type, Inc.

Lynch, A. (1987). Type development and student development. In J.A. Provost & S. Anchors (Eds.). Application of the MBTI in higher education. (pp. 5-29). Palo Alto, CA: Consulting Psychologists Press.

Mager, R. (1975). Preparing objectives for instruction. Belmont, CA: Fearon.

Mager, R. (1984). Goal analysis. Belmont, CA: Pitman Learning.

McCaulley, M. (1977). Personality variables: Modal profiles that characterize the various fields of science and what they mean for education. Journal of College Science Teaching, 7(2), 114-120.

McCombs, B. (1986). The instructional systems development (ISD) model: A review of those factors critical to its successful implementation. Educational Communications and Technology Journal, 34(2),67-81.

Macdaid, G. (1987). Research approaches using the MBTI. In J. A. Provost & S. Anchors (Eds.), Applications of the MBTI in higher education. (pp. 247-264). Palo Alto, CA: Consulting Psychologists Press.

McDonald, K., & Wheeler, D. (1986. December 10). Pervasive belief in "creation science" dismays and perplexes researchers. The Chronicle of Higher Education.

Meleca, B. (1973). Ohio State University bio-learning center uses the AT method. American Biology Teacher, 35(4), 192-197.

Merrill, M.D., & Tennyson, R.D. (1977). Teaching concepts: an instructional design guide. Englewood Cliffs: Educational Technology.

Miller, J. (1989). Scientific literacy. Paper presented at the Annual Meeting of the American Association for the Advancement of Science. San Francisco.

Miller, J., Sucher, R., & Voelker, A. (1980). *Citizenship in an age of science*. Elmsford, N.Y.: Pergamon Press.

Mitman, A., Mergendoller, J., Marchman, V., & Packer, M. (1987). Instruction addressing the components of scientific literacy and its relation to student outcomes. *American Educational Research Journal, 24*(4), 611-635.

Myers, I.B., & McCaulley M.H. (1985). *Manual: A guide to the Development and Use of the Myers-Briggs Type Indicator*. Palo Alto: Consulting Psychologists Press.

Myers, I.B. (1980). *Gifts differing*. Palo Alto: Consulting Psychologists Press, Inc.

Nabor, S. (1989). Statistical consultant, mathematics department. Personal Communication.

National Assessment of Educational Progress (NAEP). (1979). *Attitudes towards science: a summary of results*. Denver: N.E.E. Report No. 08-S-02.

National Commission on Excellence in Education. (1983). *A nation at risk*. Washington, DC: U.S. Department of Education.

National Science Board Commission on Precollege Education in Mathematics, Science and Technology, (1983). *Educating Americans for the 21st Century*. Washington D.C.: National Science Foundation.

Novak, J. (1987, September). Metacognitive strategies to help students learn how to learn. *NARST News, (29)*3.

Novak, J., & Gowin D. (1985). *Learning how to learn*. New York: Cambridge University Press.

Novak, J. (1981). Project synthesis. In P. Blosser (Ed.) *Information bulletin 2*. Columbus, OH: ERIC Clearinghouse for Science, Mathematics and Environmental Education.

Oliver, W.P. (1985). *Videodiscs in Vocational Education*. ERIC Clearinghouse on Adult, Career and Vocational Education. Columbus, OH: The National Center for Research in Vocational Education.

Peterson, T. (1989). A comment on presenting results from cogit and probit models. American Sociological Review.

Peterson, N., & Jungck, J. (1988). Problem-posing , problem solving, and persuasion in biology education. Academic Computing, 2(6), 14-17, 48-49.

Piaget, J. (1972). Intellectual evolution from adolescence to adulthood. Human Development, 15, 1-12.

Postelthwaite, S., Novak, J., & Murray, H. Jr. (1972). The audiotutorial approach to learning. Minneapolis: Burgess Publishing Co.

Provost, J., & Anchors, S. (1987). Applications of the Myers-Briggs Type Indicator in higher education. Palo Alto, CA: Consulting Psychologists Press.

Reeves, T. (1986). Research and evaluation models for the study of interactive video. Journal of Computer-Based Instruction, 13(4), 102-106.

Roberts, D. (1982). Personalisty and media preferences of community college students. Research in Psychological Types, 5, 84-86.

Santostefano, S. (1978). A biodevelopmental approach to clinical child psychology: Cognitive controls and cognitive control therapy. New York: John Wiley & Sons.

Santostefano, S. (1985). Cognitive control therapy with children and adolescents. New York: Pergamon Press.

Sharma, S. (1987). Learners' cognitive styles and psychological types as intervening variables influencing performance in computer science courses. Journal of Educational Technology Systems, 15(4), 391-399.

Shipman, S. & Shipman V. (1985). Cognitive styles: Some conceptual, methodological, and applied Issues. Review of Research in Education, 12, 229-291.

Shylo, K. R. (1985). The interrelationship of demographic characteristics, Myers-Briggs personality preferences and perceived competence of career education coordinators. Dissertation Abstracts International, 46, 03A, 575. (University Microfilms No. 85-10634)

Steele, G. E. (1986). An investigation of the relationship between students' interests and the curricular practices of an alternative high school, through the perspective of Jung's theory of psychological types. Dissertation Abstracts International, 47, 10A, 3616. (University Microfilms No. 86-25301).

Stevens, D. (1983, Summer). Cognitive processes and success of students in instructional computer courses. Association for Educational Data Systems Journal. In S. Sharma (1987). Learners' cognitive styles and psychological types as intervening variables influencing performance in computer science courses. Journal of Educational Technology Systems, 15(4), 391-399.

SAS. (1983). SUGI Supplemental Library Users' Guide. Cary, NC: SAS Institute, Inc.

Tamir, P. (1985). Meta-analysis of cognitive preferences and learning. Journal of Research in Science Teaching, 22(1), 1-17.

Tanenbaum, R. (198). An investigation of the relationship(s) between selected instructional techniques and identified field dependent and field independent cognitive styles as evidenced among high school students enrolled in studies of nutrition (Doctoral Dissertation, St. John's University, 1981). Dissertation Abstracts International. (43, 68.)

Thompson, B. (1984). Canonical correlation analysis. Beverly Hills: SAGE Publications.

Tillman, M. (1979, August). An examination of the productive validity of several potential predictors of the work proficiency of computer programs. Computer Personnel. pp. 3-6. In Sharma, S. (1987). Learners' cognitive styles and psychological types as intervening variables influencing performance in computer science courses. Journal of Educational Technology Systems, 15(4), 391-399.

Tobias, S. (1982). When do instructional methods make a difference? Educational Researcher, 11(4), 4-9.

Voelker, A.M. (1982). The development of an attentive public for science: Implications for science teaching. In R.E. Yager (ed.), What Research Says to the Science Teacher. Washington, DC: NSTA.

Walberg, H. (1983). Scientific literacy and economic productivity in international perspectives. Daedalus, 12(2), 1-28.

Warmbrod, J. (1987). Agriculture Education 995 class handout.

Weade, R. (1984). The relationship between Jungian psychological type and curriculum design preference (teaching role, curriculum role). Dissertation Abstracts International, 45, 6A, 1633. (University Microfilms No. 84-19030)

Welch, W., Harris, L., & Anderson, R. (1984). How many are enrolled in science? The Science Teacher, 51(9), 14-19.

Westheimer, F. (1987). Are our universities rotten at the "core"? Science, 236,(4806), 1165-6.

Wheatley, J.H. (197). A scheme for evaluating the audio-tutorial biology laboratory in the cognitive/affective domains (Doctoral Dissertation, The Ohio State University, 1972). Dissertation Abstracts International, 33. 4971.

Witkin, H., & Goodenough, D. (1981). Cognitive styles: essence and origins, field dependence and field independence. New York: International Universities Press, Inc.

Witkin, H.A., Oltman, P.K., Raskin, E., & Karp, S.A. (1971). A manual for the Embedded Figures Test. Palo Alto, CA: Consulting Psychologists Press.

Wivagg, Dan. (1987). High school biology textbooks and college biology teaching. American Biology Teacher, 49(2), 71.

Wood, C. (1989). Personal communication.

Yager, R.E. (1984). Science and technology in general education. In Bybee, R.W., et al., (Eds.), Redesigning Science and Technology Education, Washington DC: National Science Teachers Association.

Yager, R.E. (1986). What's wrong with school science? The Science Teacher, 53(1), 145-147.

Yager, R.E., & Penick, J. (1987). Resolving the crisis in science education: Understanding before resolution. Science Education, 71(1), 49-55.

Yap, K., & Yeany, R. (1988). Validation of heirarchical relationships among Piagetian cognitive modes and integrated science process skills for different cognitive reasoning levels. Journal of Research in Science Teaching, 25(4), 247-281.